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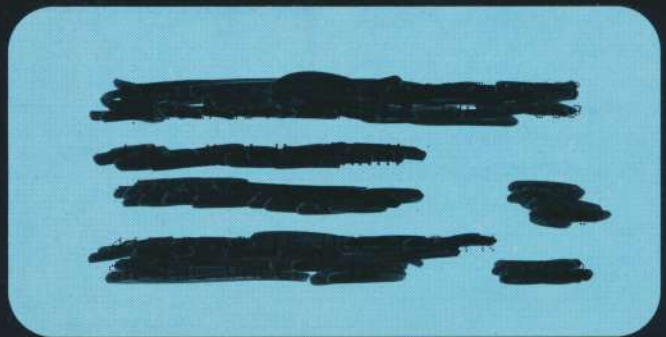

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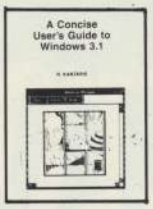

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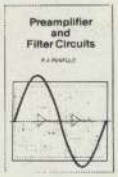

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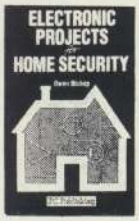

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CONSTRUCTION ARTICLES

REDUCE HEATING COSTS WITH THE FUEL MISER ..... Anthony J. Caristi 35
Tame home-heating costs without sacrificing comfort with this furnace controller

BUILD AN ACTIVE ANTENNA ..... Fred Blechman 46
Lift hard-to-hear HF/VHF/UHF radio signals into the clear with this receiver accessory

BUILD A TURN-SIGNAL REMINDER ..... Jim Stephens 61
Avoid certain embarrassment, and possible accidents, with this automotive accessory

AN ELECTRONIC GONG ..... Terry Pinnell 63
Replace that raspy sounding mechanical buzzer with a pleasant-sounding electronic substitute

FEATURE ARTICLES

ELECTROMAGNETIC FIELDS AND YOUR HEALTH ..... John Iovine 31
Learn why there's so much concern about low-frequency electromagnetic radiation, and build a circuit to detect it around your home

SENSORS MADE SIMPLE ..... Stephen Bigelow 40
Find out what sensing devices are available to you and develop your own circuits around them

555 MONOSTABLE CIRCUITS ..... Ray Marston 53
Learn how to use the versatile 555 timer chip in practical circuits

SMART CARS FOR SMART HIGHWAYS ..... Bill Siuru 56
These new technologies promise to make cars, and the roads they drive on, safer and more efficient

PRODUCT REVIEWS

GIZMO 5
Including: Davis Instruments Weather Monitor II, Accu-Weather On-Line Weather Station, Sony 8mm Camcorder, and much more

HANDS-ON REPORT 22
TSM 3-Digit Voltmeter Kit

PRODUCT TEST REPORT ..... Len Feldman 27
Sony STR-D990 Audio/Video Receiver

COLUMNS

ANTIQUE RADIO ..... Marc Ellis 66
Electronic espionage—World War II style

COMPUTER BITS ..... Jeff Holtzman 68
Creative thinking

CIRCUIT CIRCUS ..... Charles D. Rakes 70
Using stepper motors

THINK TANK ..... John Yacono 73
Counting in binary

DX LISTENING ..... Don Jensen 76
SW since the USSR breakup

HAM RADIO ..... Joseph J. Carr 78
Direct conversion receivers

SCANNER SCENE ..... Marc Saxon 80
Scanning the final frontier

DEPARTMENTS

EDITORIAL ..... Carl Laron 2
LETTERS 3
FACTCARDS 49
POPULAR ELECTRONICS MARKET CENTER 50A
FREE INFORMATION CARD 51
ELECTRONICS LIBRARY 82
NEW PRODUCTS 86
ELECTRONICS MARKET PLACE 95
ADVERTISER'S INDEX 97

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EDITORIAL

ELECTROMAGNETIC FIELDS AND YOUR HEALTH

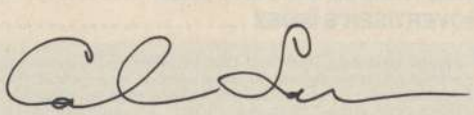
What do TV's, VCR's, computer monitors, electric razors, electric clocks, hair dryers, and fluorescent lights have in common? They are common sources of low-level, ELF (extremely low frequency) radiation in and around your home.

Until recently, such electromagnetic fields have been thought to be too weak to do the human body any harm. However, some studies have shown the opposite to be true. Now, scientists are taking a second look at these fields and the potential damage they can do.

The jury is still out on whether or not we should be concerned about ELF exposure. For instance, while there is statistical evidence that ELF fields pose a potential health risk, the biological mechanisms involved are not fully understood. Further, the effects of factors such as length of exposure, frequency of the field, etc. are still being researched.

That uncertainty has not stopped a "boomlet" of ELF-related products from hitting the market. You can obtain ELF monitors from a number of sources. Computer-monitor makers are touting their reduced-radiation units (at a premium price, of course). And a multitude of ELF-reduction accessories (some of dubious value) are being offered.

This month, **Popular Electronics** turns its attention to the ELF question with the article "Electromagnetic Fields and your Health." In it, we present a summary of some of the research to date so that you can form your own opinion. We also present some simple precautions you can take to minimize your exposure to ELF fields. There's even a simple, low-cost ELF monitor that you can build to search out sources of electromagnetic radiation in your home or workshop. The story begins on page 31.



Carl Laron
Editor

LETTERS

PRICING CHANGE

We have been informed by Philips that the prices of their Instant-Cross Software, reviewed in the December, 1992 issue, has gone up since the article was prepared. The new prices are as follows: 5¼-inch, 1.2M disks (literature No. ET-2602), $8; 5¼-inch, 360K disks (literature No. ET-2603), $11; 3½-inch, 720K disks (literature No. ET-2604), $9.25. We are sorry for any inconvenience that this has caused.—Editor.

NOT ANOTHER COMPLIMENT!

Applause for **Popular Electronics**! The article "Not Another Op-Amp Article" (December, 1992) was great. I realize that it is not practical to run basic electronics lessons throughout the magazine, but I still would like to see at least one article covering theory on the basics each month.

Yes, I had electronics courses in the military and in college—but if you don't use it, you lose it. A lot of electronic technician jobs today don't require the use of the basics in practice. Also, things change through the years in this industry.

S.D.
Casselberrry, FL

MOBILE MAGNETIC COMPASS

Larry Mitschke's article called "Build a Talking Compass" (**Popular Electronics**, December 1992) has brought many inquiries on our No. 1490 Sensor, the heart of his compass design. Although his design is for a hand-held compass, many people have asked "How does one make a magnetic compass work in an auto?"

That is a rather large and complex field in which our company has excelled for the past 65 years. The greatest problem confronting the accuracy of a magnetic compass is the massive magnetic anomaly created by and built into a vehicle. The magnetic force driving our compass is the Earth's microscopic horizontal field, which is only 0.18 gauss in our area. Many automobiles have a built-in magnetic anomaly 8.3 times *stronger*, up to 1.5 gauss.

How to counteract the vehicle's magnetic anomaly requires much more space than this letter occupies, so, to accommodate any of your readers who might be interested in a fuller discussion of making a magnetic compass function in their vehicles, we will mail the information on receipt of a stamped, self-addressed envelope.

R.C. Dinsmore
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1814 Remell Street
Flint, MI 48503

HAVES & NEEDS

I am looking for a book that has been out of print for some time now. It is titled *Transistor Ignition Systems*, and was written by Carroll A. Brant. The book was published by Tab in 1977 (book No. 882).

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MARCH 1993

VOLUME 6, NUMBER 3

You Don't Need a Weatherman...

ACCU-WEATHER FORECASTER ON-LINE WEATHER STATION. From The Software Toolworks, 60 Leveroni Ct., Novato CA 94949. Price: $49.95 plus subscription and connect-time charges.

"You don't need a weatherman to know which way the wind blows." So sang Bob Dylan on his classic "Subterranean Homesick Blues." But to get a reasonably accurate idea of what the weather will do tomorrow, the day after, or even further down the road, most people *do* need a weatherman. Unfortunately, that usually means that you have to put up with the inane patter between the local news anchor and the weatherman.

Because of our extreme intolerance of such gibberish, we would usually just turn down the volume, watch the colorful weather maps and satellite images that show up on-screen, and get a fairly good idea of what to expect for the next couple of days. Now, however, Dylan's lyrics seem prophetic. We don't even have to turn on our TV to get the same flashy graphics and weather-satellite data that the forecasting pros get. We can download them with our modem using the *The Software Toolworks' Accu-Weather Forecaster.*

The Accu-Weather Forecaster software is basically a user-friendly front-end for accessing the Accu-Data computerized database—the same database where many professional forecasters get their information. According to Accu-Weather, more than 35,000 reports are available on-line. We didn't count them, nor did we get to sample most of them. But we were amazed at what we were able to see and access.

Although the Forecaster is available for the Macintosh, we tested the IBM PC (and compatible) version. It requires that your PC has 640 kilobytes of memory, and EGA or VGA graphics capability. A hard disk, although not strictly required, is virtually essential.

The user interface is through a series of pull-down menus: File, Telecom, Display, Select, and Setup. The first step after installing the software is to pull down the Setup menu and enter such data as what the nearest National Weather Service station is, and which are the closest stations that provide text information and charts. (An appendix in the owners manual lists stations by state, and indicates their reporting capability.) In our tests, we set our closest and chart-reporting stations to Islip, Long Island, where a local airport is located. Since Islip does not support text reporting, we set our text station to the New York City forecast office. The Setup menu is also the place to enter your modem configuration information, your printer type, and the drive and directory where you want to store downloaded information.

Once you've configured the software, it's time to think about what weather data you want to download from Accu-Data. By going to the Telecom menu, you can pre-define your data requests. Once you define what you want, you can make the call and walk away from the computer—the Forecaster downloads any data and images that you defined, and then hangs up automatically. After the data is downloaded, you can display the graphics and chart and manipulate the data without additional connect time.

Buying the Forecaster package entitles you to an hour of connect time to Accu-Data. During that hour, you must subscribe to the service through one of the available packages. (There are two sets of rates: one for commercial and one for non-commercial use. All prices referenced here are for personal use.) Three subscription options are available: "one-month sampler," "three-month special," and "super saver."

CIRCLE 50 ON FREE INFORMATION CARD

TURN PAGE FOR CONTENTS

This month in GIZMO®

The Software Toolworks Accu-Weather Forecaster On-Line Weather Station ..... pg. 5

Davis Instruments Weather Monitor II Personal Weather Station and Weatherlink Software..... pg. 7

Innova Electronics Power Charger Battery Charger ..... pg. 12

Yamaha RX-V1050 Audio/Video Receiver..... pg. 14

Sony CCD-TR31 8mm Handycam Camcorder..... pg. 17

Pioneer 300-Disc CD Changer System..... pg. 20

Sherwood Automotive AM/FM/CD Player..... pg. 20

Executive Travelware Clock Radio ..... pg. 21

Jasco Universal Remote/VCR Programmer..... pg. 21

Ricoh Hi-8 Camcorder..... pg. 21

Sanyo Cordless Phone ..... pg. 21

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The one-month sampler costs $39.95. With it you get one free hour of connect time, and the first $15 of actual usage during the first month is free. There is no monthly minimum charge for the first month; after that, there is a minimum $9.95 connect-time charge.

The three-month special costs $49.45 and also comes with an hour of connect time. The first three months have no monthly minimum charge; after the three months, the $9.95 minimum applies. The first $10 of actual usage during the first three months is free. The super-saver package also comes with an hour of connect time, and gives you a year with no monthly minimum charge. After the year, a $9.95 minimum applies. The first $10 of actual usage during the first twelve months is free. With any of the subscription packages, you are entitled to use Accu-Weather's toll-free telephone access numbers.

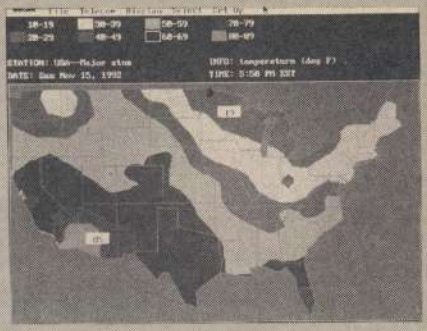
The connect-time rates range from a low of 10 cents per minute from midnight to 5 AM, to 19 cents per minute from 7 PM to midnight, and 39 cents per minute for the rest of the day. A 50% surcharge is tacked onto those rates for 2400-baud modem users.

The types of data you can request for automatic download is quite large. If you select "Define New Request" in the Telecom menu, you are presented with three choices: "Hourlies and Forecasts," "TV Graphics—Part 1," and "TV Graphics—Part 2." Each of the items can be turned on or off; each item has a sub-menu where you can define just how you want the data. Let's look at a few examples.

When you request hourly readings and forecasts, you can select specific National Weather Service stations or you can pick an area on a map of the U.S. in which you're interested. You can also download data from 100 major U.S. stations for a nationwide picture of the weather, and even download a text summary of the U.S. weather.

The first TV graphics menu lets you select the images in which you're interested. Surface maps, which are hand-drawn national maps, are available for current conditions as well as one- and two-day forecasts. Satellite images, (enhanced images gathered from the GEOS satellite) are available for a variety of areas, including full U.S., regions of the U.S., Mexico, and even the world. 3-D images are satellite photos enhanced to show the height of cloud formations. U.S. and regional Radar Plus images (which are composites of reports from weather-radar installations across the country) provide information on the intensity of precipitation. Radar Plus SIR (snow, ice, rain) images show the type of precipitation.

The second TV graphics menu provides



After you log off the Accu-Data system, you can display your downloaded data in various formats. Here, the nation's temperatures are shown by colored bands, with the high and low temperatures indicated.

a variety of graphics that is too wide to detail. But we can give some examples. A look at soil moisture is available, as is a picture of snow cover. For forecasting, a look at the jet stream is provided. What's the weather in the morning going to be? You can find that out too. Maps showing tonight's low and tomorrow's high temperatures are available, as is one showing where extreme weather is happening.

All the data takes time to download, of course, and the images take up disk space. A typical satellite image can be downloaded in a little over a minute at 2400 baud; it requires about 60 kilobytes of disk space to store. (You can choose to automatically save or delete old images.)

Once the data is downloaded and your connection with Accu-Data broken, you can examine the data in detail at your leisure. TV graphics can be called up from the Display menu. You can select to view the latest image of one particular type, or you can loop through the images from the earliest to the latest in order. That's helpful to get an idea of the movement of weather systems and storms.

The textual data can also be displayed on-screen. Downloaded information from various weather stations can be displayed on maps. Let's say you chose to download the information from the 100 major stations of the National Weather Service. You can display the information—temperature, pressure, dew point, wind direction and speed, wind gust, visibility, and more—on a map of the U.S. You can display the actual values of the data, or you can draw shaded or colored bands to show the weather conditions, much like the maps you see in your local newspaper.

The data you can get from your request is more than adequate for most casual, and many serious, users. But it's only a small part of the more than 35,000 data types you can get from Accu-Data. That's where the "Explore Accu-Data" menu option comes in. After the software dials Accu-Data and logs you in, you're presented

with an on-line menu system. Since we had a copy of the Accu-Data User's Guide (available for $18.50 plus shipping from Accu-Weather, 619 W. College Ave., State College, PA 16801), we left the menu system and explored various commands on our own.

Using Accu-Data, you can look at weather conditions virtually anywhere in the *world*. You can plot the data using AMPS, Accu-Weather's Advanced Map Plotting System. Dozens of standard map backgrounds are available, but you can make your own, too, by providing the latitude and longitude of the map canter, the size of the map, and the map projection.

The data that you can plot on the maps include temperature, pressure, dew point, wind speed and direction, cloud cover and ceiling, and more. Plots of upper-air parameters can also be obtained.

One of the most fascinating AMPS capabilities was the real-time lightning-strike map. Each lightning strike shows up as an on-screen dot as it occurs. It's possible to immediately see the path of severe thunderstorms as they head toward you.

A wide variety of eye-catching enhanced satellite images are available from the Accu-Weather Forecaster

All the data in the world won't necessarily help you to forecast what tomorrow's weather will be unless you know how to interpret it. Detailed weather-map discussions can be downloaded. They indicate the rationale for various portions of the forecast, and what changes might be made in the next forecast issued.

Of course, it's more fun to make your own predictions. The 37-page Forecasting Guidebook supplied with the software will leave the serious weather hobbyist yearning for more information. It does, however, do a good job in explaining the basics.

We had a lot of fun using the Accu-Weather Forecaster. But it's practical, too. Frequent travelers, for example, will appreciate the ability to download local forecasts from the National Weather Service. And everyone will appreciate being able to hit the mute button whenever some annoying local weatherman starts his routine. ■

Weathering Heights

WEATHER MONITOR II PERSONAL WEATHER STATION AND WEATHERLINK SOFTWARE; from Davis Instruments, 3465 Diablo Avenue, Hayward, CA 94545; Price: $295 (Weather Monitor II) and $150 (Weatherlink).

"Everybody talks about the weather, but nobody does anything about it."

If you're looking for a gizmo that will let you do something about the weather, sorry, we can't help. As far as we know, no one has yet developed a cloud seeder for consumers, or a remote-controlled thermostat for the sun. What we can tell you about, however, is a device that will allow you to talk more knowledgeably about the weather—without relying on TV or radio forecasts.

Predicting the weather is a risky business. Who among us hasn't had a picnic rained out when the weathermen had predicted a sunny day, or postponed a trip to the beach due to a bad forecast only to find yourself sitting home on a beautiful afternoon? Monitoring the weather, on the other hand, is a precise science. *Davis Instruments' Weather Monitor II* allows you to make weather measurements, store data in memory, and recall record highs and lows. The basic system measures temperature (indoors and outdoors), wind speed and direction, barometric pressure, and inside humidity, and even determines the wind-chill factor. Using optional accessories, you can also measure the outside humidity and rainfall. Using *Weatherlink* software, which we describe below, it's possible to track your findings, create graphs, calculate average weather conditions, generate summaries, and analyze trends over various time periods.

The Weather Monitor II includes the main unit, which Davis calls the Weather Computer; an external temperature sensor with 25 feet of cable; an anemometer with 40 feet of wire, a wind vane, and cups; an AC power adapter; a junction box and an 8-foot cable; and the hardware needed for installation.

Proper installation of the system is crucial, and, as you might expect from a task that involves climbing out on the roof and making precision calibrations, setup is not simple. Luckily, Davis supplies an owner's manual that is one of the best we've seen. It provides concise instructions, in plain English, with plenty of illustrations.

Figure 1 shows a typical installation. The anemometer is attached to a TV antenna, the external temperature sensor (or the optional temperature/humidity sensor) is placed in a protected spot under the eaves, and the optional rain collector is mounted on the roof. Installation requires cable clips or weather-resistant ties, assorted hand tools, and a handheld magnetic compass; a carpenter's level and an electric drill might come in handy, too.

The amemometer should be mounted at least four feet above the roof line, so that

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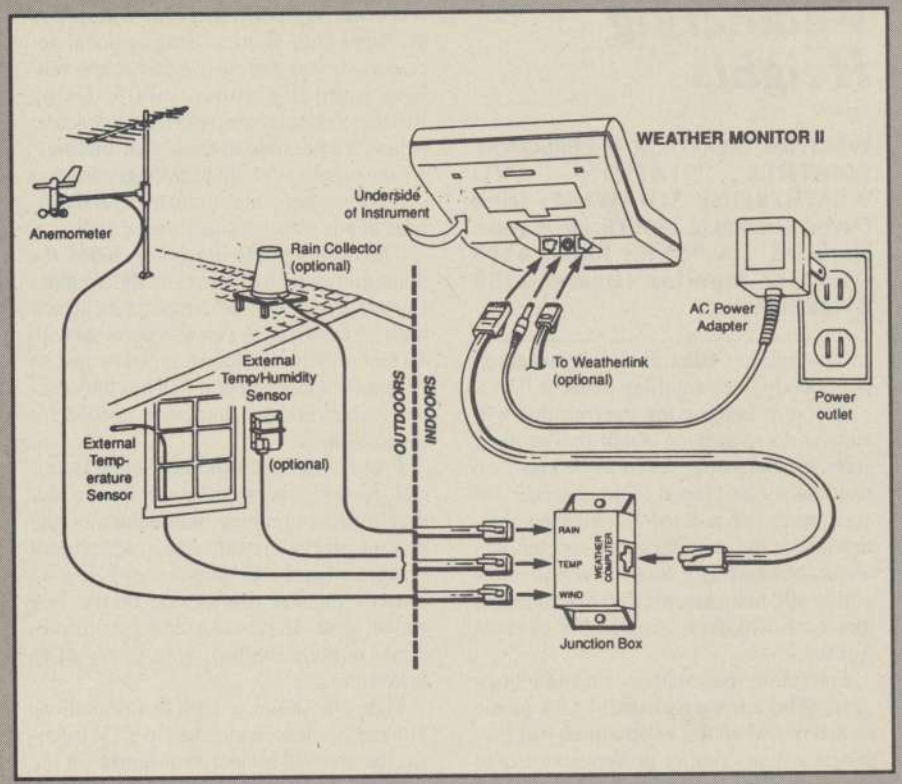


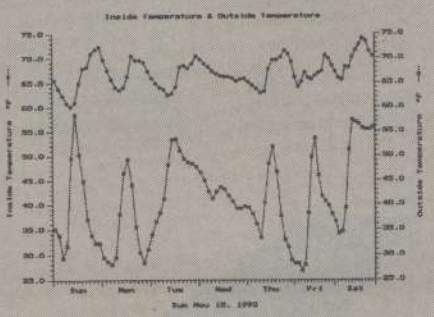
Fig. 1. Accurate weather readings depend upon proper installation of the Weather Monitor II's sensors, wind vane, and optional rain-collector, as depicted in this illustration from Davis' excellent user's manual.

it—and the wind it measures—is free from obstructions. Wind-direction calibrations are done using a compass to determine which direction the anemometer is pointing, and a wind-direction chart to find the corresponding degree reading.

The temperature sensor must be placed in a location that is shielded from rain (which could affect the accuracy) and direct sunlight (which could damage the sensor and cause false readings). It should not touch the side of the house. It should be placed on the north side of the house, unless you live in the Southern hemisphere, in which case the south side is preferred.

The junction box, which connects the sensors to the Weather Computer, isn't moisture- or dirt-resistant, so it must be installed indoors. Davis recommends keeping it off the floor to avoid dirt and accidental impact.

The Weather Computer itself contains internal temperature and humidity sensors, so its placement is also critical. The unit's mounting base allows it to be set up vertically (on a shelf, for instance) or horizontally (on a desk). It can also be wall-mounted, using an empty electrical switch box and running the junction cable through the walls. It shouldn't be mounted on an outside wall that might heat up or cool down with the weather. Nor should the main unit be placed near heating units,



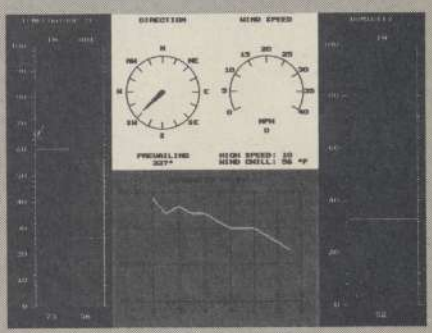
A chart depicting indoor (top line) and outdoor (bottom line) temperature changes over a one-week period.

air-conditioners, or in direct sunlight. If you plan to use the Weatherlink software, the unit will be mounted near your PC, but it shouldn't be placed directly on top of any device that gives off heat.

With the anemometer up on the antenna, the rain collector on the rooftop, the temperature sensor under the north eaves of the house, and the Weather Computer mounted in your home office, there's a good chance that you'll have to avail yourself of the extension cables that are optionally available.

The Weather Computer runs on 9-to-12-volts DC; an AC power adapter is included. To protect the data stored in memory, a 9-volt battery should be used as a backup power supply. That battery will provide 24–48 hours of use in the event of power outages—which are often caused by the storms during which you'll get some of your most interesting readings. For use in cars, boats, or recreational vehicles, a DC cigarette-lighter cord is available optionally. We'd imagine the Weather Monitor II would come in handy on camping trips or long sailing trips.

The top half of the Weather Computer is tilted up to enhance its large display. The left side of the display contains a graphic "compass rose," a circle divided into 16 points that each correspond to a different compass point 22.5° apart. A flashing arrow within the circle indicates wind direction; wind speed is indicated numerically within the circle. What's displayed on the right side changes according to user-selected function. With the basic Weather Monitor II (no options), you can display the time or date, indoor or outdoor temperature (in 1° or 0.1° increments, Fahrenheit or Celsius), wind chill, indoor humidity, or barometric pressure. At the bottom-right side of the display the barometric trend is indicated by an arrow that points upward or downward depending on recent barometric readings.



Weatherlink's "Bulletin Screen" provides a direct link to the weather data currently being collected by the Weather Monitor II.

The bottom half contains two rows of "buttons" (actually, membrane touch pads). The upper row is used to select the element to be measured: TEMP, WIND, WIND CHILL, RAIN, BAR (barometer), HUM (humidity), and DEW. The lower row contains seven function keys used to set parameters and activate (or deactivate) various features. For instance, to set the time you would first press the TIME key, then UNITS to select either 12- or 24-hour format, and then use the ENTER key to change the hour and then the minutes. The UNITS key is also used to select Fahrenheit or Celsius for temperature measurements; miles per hour, kilometers per hour, or meters per second for wind speed; and barometric pressure in inches of mercury, millimeters of mercury, or millibars. The CLEAR button resets or clears data or instructions from the unit's memory.

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The Weather Computer measures inside temperatures from 32°F to 140°F, outside temperatures from −50°F to 140°F, wind speeds to 126 mph, and wind direction in 1° or 10° increments. It also records high and lows for most of its functions. You can track daily, weekly, monthly, yearly, or all-time highs and lows, depending on how often you clear them from memory. Highs and lows are displayed by pressing RECL once or twice.

The device isn't called the Weather Computer for nothing. Its microprocessor uses its readings of temperature and wind speed to automatically calculate the wind-chill factor. Other computer functions include the alarm and scan features. A set of alarms can be programmed to sound whenever certain thresholds that you have set are reached (low or high temperature, high winds, etc.). If, for example, you keep your dog out in the yard, but prefer to bring him in the house when the temperature drops below 40°F, you could set an alarm by pressing TEMP to display the outside temperature, followed by ALARM. Next, you would use ENTER to set the alarm to 40°F, and then press TEMP again to exit. In Auto Scan mode (entered by pressing SCAN), each of the readings is displayed for about four seconds in a preprogrammed order. You can also program and store one customized scan routine.

Used on its own, the Weather Monitor II provides a wealth of data. But when you add Weatherlink software, things get really interesting—and fun. The IBM-PC-compatible program stores and manipulates all the data that has been collected by the Weather Monitor II system at user-specified 1-, 5-, 15-, 30-, 60-, or 120-minute intervals. The Weatherlink comes with both 9- and 25-pin RS-232 serial port adapters and eight feet of cable.

Once the data has been downloaded, you can display it on screen; various charts and graphs show each of the parameters being measured by the Weather Monitor II. You can also make up your own graphs. It's possible to graph any function on a daily, weekly, monthly, or yearly basis. You can plot two different time periods on the same screen, so you can compare this year's temperatures to last year's, for instance. You can also plot two different variables on the same graph, for a visual display of how rainfall is related to barometric pressure, for example. And if you have more than one Weather Monitor II (and a Weatherlink for each), you can track weather information from all of them—even in remote locations. An optional modem adapter lets you keep track of weather conditions up at your ski house—if you're lucky enough to have one. The data can be stored on a hard or floppy disk, and can be exported to Lotus 1-2-3- or dBase III-compatible software. Finally, you can print out your results on almost any dot-matrix or laser printer.

So, the next time you go to the office on a bright and sunny morning and find your co-workers grousing about how it seems to rain only on weekends—every weekend—you can pull out charts showing precisely how much rain had fallen on Saturday and Sunday each week, and what the temperature was as well. That might not get you any more sunny days off, but it's sure to impress—or annoy the hell out of—your friends.

Ben Franklin once said, "Some people are weatherwise, but most are otherwise." The Weather Monitor II, particularly when used with Weatherlink software, puts you firmly in the "weatherwise" group. ■

Charge It!

POWER CHARGER CORDLESS BATTERY CHARGER. From: Innova Electronics Corporation, 17287 Mt. Hermann Street, Fountain Valley, CA 92708. Price: Less than $100.

A few years ago, we took a trip to San Francisco that was a close-to-perfect vacation. It was, unfortunately, marred by the trip home. The problem wasn't that we were bumped from our flight—we were, but the airline generously reimbursed us for our trouble, and then put us in the only available seats on the next flight out, which just happened to be in first class. Under those circumstances, we didn't even mind that we'd be arriving at Kennedy Airport after midnight on a Sunday night, although we'd still have to deal with the baggage claim, what seemed like a half-hour bus ride to the long-term parking lot, and an hour's drive home from there. We didn't mind, that is, until we reached our car and realized that, in our rush to catch our outgoing flight, we had left one of the doors slightly ajar and thus the interior dome light was on. At least it *had* been on—when we'd parked the car two weeks earlier! By the time we were finally ready to drive home, at 1 AM on a cold November night, the battery had been long dead.

Things could have been worse: If that security guard hadn't been driving by, we'd have had to wait for the next shuttle bus back to the main terminal to telephone a tow truck. As it was, the guard made the call for us, and we only had to wait forty minutes or so for the tow truck to arrive. (Then, on top of paying for his services, we had to pay the hefty minimum parking fee charged by the airport for the truck merely entering their long-term parking lot.) We made it home eventually, but the experience put a damper on our vacation.

At best, dead batteries are annoying. At worst, they can put a person in a dangerous position, stranded and vulnerable. There are a few ways to keep from finding yourself in such a position (besides making sure you close your car doors before getting on a plane!): You can carry jumper cables and hope that some good Samaritan comes along to give you a jump, or maintain membership in the Automobile Association of America, who will come and give you a jump, as long as you can get to a phone to call them.

Now, however, there's a solution for those who'd prefer not to depend on the kindness of strangers or the proximity of a public phone—the *Power Charger* from *Innova Electronics*. The Power Charger is a 15-volt, 10-amp, cordless battery charger that in 15 to 30 minutes can provide vehicle batteries with enough of a charge to start the engine. If you prefer not to clutter your trunk with gadgets that you might end up using at best infrequently (unless you're driving a real lemon), never fear. The Power Charger earns its trunk space by doubling as a portable power source for any 12-volt DC accessory, and "tripling" as a charger for 12-volt battery packs and cellular-phone batteries.

The Power Charger is the general size and shape of some of those old-time "portable" radios. It measures about 7 × 10 × 3 inches, weighs eight pounds, and has a built-in carrying handle and an adjustable shoulder strap. The built-in male plug for recharging the internal battery and charging other batteries stores conveniently inside the carrying handle. Along the top front of the unit are a three-way *12 v power/off-recharge/15 v charger* switch and three LED's—green, yellow, and red—which indicate the status of the unit in each of its various functions. On the front of the unit, hidden behind a cap, is a 12-volt/15-volt DC fused (negative ground) female socket. On each side of the unit are modular side mounts and modular contacts (12-volt/15-volt DC fused) that can be used to connect various accessories. The Power Charger also comes with a set of clamps that let you hook it directly to a battery—ideal for vehicles without working cigarette-lighter sockets.

To recharge a vehicle battery, after closing the door and turning off any accessory (such as the radio) that might draw power, you simply insert the male plug into the cigarette lighter socket and select 15 v CHARGER. The yellow LED should light, indicating that the connection has been

made and charging has begun. (In some instances, it's necessary to turn the ignition switch to the ACCESSORY position before the yellow light comes on.) According to Innova, a feature called "three volt boost" pushes the unit's output to 15 volts—about the same voltage provided by a car's alternator—so that it, too, can charge a 12-volt vehicle battery. After you plug it in, it's a matter of waiting anywhere from 15 to 30 minutes for the battery to charge enough to start the vehicle.

For vehicles without cigarette lighters, the procedure is only sightly more complex. There is a receptacle for the male plug on the direct battery clamps. Once the plug is inserted, the clamps must be connected as you'd connect standard jumper cables—the black clamp to the negative post of the battery and then the red clamp to the positive post. Again, after that it's a matter of waiting for the charge to build up to a point that is sufficient to start the car.

The main advantage of the Power Charger, to our way of thinking, is that there's no need to leave the safety of your car (except to get it out of the trunk). In fact, as long as you have a working cigarette-lighter receptacle, you don't even have to open the hood and call attention to your helpless predicament. There's no long walks to a phone booth, no waiting for a tow truck, and no maneuvering another car close enough to yours to connect jumper cables.

Keep in mind that the Power Charger isn't providing a full charge, but a temporary fix. Innova recommends that, after having used the Power Charger to boost your battery, you have the battery fully charged as soon as possible. Of course, your car's charging system should recharge the battery provided the system is not faulty, which might be what caused the battery to fail in the first place. In such an instance, the Power Charger obviously won't be of much help.

In our tests, on a 1986 Toyota Corolla with a 3-year-old Delco Freedom battery, the Power Charger worked as promised. We purposely (for a change) ran down the battery by leaving the lights on for a few hours. When the battery was dead, we plugged the Power Charger into the cigarette-lighter receptacle and moved the toggle switch to 15 VOLT CHARGER. When nothing happened, we turned the key to ACCESSORY. The Power Charger's yellow LED lit up, and within a half hour, the car started up with no trouble at all. A half-hour drive at highway speeds left us confident that we wouldn't have to worry about an under-charged battery.

Fortunately, dead batteries typically are not a frequent occurrence, and most of the use you'll get out of the Power Charger will be under less stressful, generally enjoyable, circumstances. In its "PowerPack" mode, it can be used to run any 12-volt DC product that has a male cigarette-lighter plug (or an optional modular accessory can be used). Hams, in particular, will find it a useful power source for their mobile rigs. It can also be a safe power source for notebook computers. The device can be used to power a cellular phone for up to 10 hours of talk time, or 100 hours in standby.

CIRCLE 52 ON FREE INFORMATION CARD

To use the device in its PowerPack mode, the switch is moved to the "off" setting, and the male plug is inserted into the female socket on the front of the Power Charger. For products that don't come with a male cigarette-lighter plug, the modular accessory slides onto the side mount for connection. The green LED lights to indicate that all systems are go, and you simply turn on your transceiver, computer, or whatever.

In addition, you can use the Power Charger to recharge the other 12-volt battery packs, such as those for camcorders, that have a male lighter plug or a female lighter socket attached. Once the battery pack is connected, the Power Charger's switch is turned to the 15 V CHARGER position, and the lighted yellow LED indicates that the connection is made and the battery is being charged.

Although it isn't mentioned in the instruction sheet, we'd imagine that you could also use the Power Charger with an inverter to run small household items in the case of a power failure.

The Power Charger's three LED's also serve to keep you aware of the device's status. A red light in the 12-volt power mode warns that there's a blown fuse that must be replaced; in the 15-volt charger mode, the red LED warns of a short circuit in the vehicle under charge. When the green LED flashes, it means that the power is low, and it's time to recharge the Charger.

Innova recommends that you recharge the Power Charger immediately after every use, and routinely charge it once every three months (even if it hasn't been used), using one of three methods. First, with the vehicle running, you can use the cigarette-lighter socket to recharge the unit in one to three hours. The second and third methods involve using optional accessories: The AC/DC Charger, a 12-volt wall transformer, recharges the Power Charger overnight (8 to 10 hours); the Trunk Charger, a

(Continued on page 20)

Wide (Soundfield) Receiver

YAMAHA RX-V1050 AUDIO/VIDEO RECEIVER. From: Yamaha Electronics Corporation, USA, 6722 Orangethorpe Avenue, Buena Park, CA 90620. Price: $1199.

CIRCLE 53 ON FREE INFORMATION CARD

Despite the sluggishness that has affected most areas of the economy—including consumer electronics—there are some bright spots. One of them is the sales of receivers. The growing popularity of home theater has given consumers a real reason to trade in their old but still-good receivers for A/V receivers that incorporate Dolby surround-sound processing and video-switching capabilities. The A/V receiver, some would argue—and we wouldn't disagree—is the most important home-theater component.

For manufacturers, the competition in A/V receivers is fierce. Everyone, it seems, is doing justice to Pro-Logic decoding. (We have yet to review a Pro-Logic receiver that we felt was audibly flawed.) While A/V receivers from different manufacturers are, indeed, similar, there are three important differences: center-channel power, DSP, and user convenience.

Yamaha takes a sensible view of center-channel power with the *RX-V1050*—the amplifier is rated to deliver 110 watts into 8 ohms to the center channel, the same as the right- and left-channel specifications. (Our laboratory tests showed that it could deliver even more.) An adequately powered center channel is important because in a Dolby-encoded soundtrack, that's where most of the action takes place. The center channel is what gets you to pay attention to the on-screen action. Virtually all of the dialogue—and quite a bit more—is in the center channel.

Most of the A/V receivers we've seen recently incorporate some form of digital signal processing, or DSP, and include such DSP modes as "hall," "theater," or "jazz club." Each manufacturer does things a little differently, however. (Even manufacturers that use the same digital signal processor chip can program it differently.)

Yamaha, the first consumer-electronics manufacturer to introduce DSP to audio in 1986 with its DSP-1, calls its particular flavor of DSP "Digital Soundfield Processing." The RX-V1050 is the first receiver to combine Yamaha's Digital Soundfield Processing with Digital Dolby Pro Logic Surround in what Yamaha calls "Cinema DSP." The intent of Cinema DSP is to provide an in-home experience that rivals the best cinema sound-system experience.

Six digital soundfield modes are provided by the receiver. First is Digital Dolby Pro Logic, which adds DSP to Pro-Logic decoding to improve crosstalk and to "transfer the sound source more smoothly and precisely," according to Yamaha. An enhanced Pro-Logic mode is also offered, in which DSP is used to simulate "the multisurround speaker systems of the 35-mm film theater" and to widen "the surrounded-sound field with greater presence." The idea is to make the surround-channel information sound as if it is coming from a movie-theater surround system (which uses many speakers around the side and back walls) instead of from two point sources in your living room.

The other modes are intended primarily for listening to music. The DSP effects simulate reflections that might be heard in various venues. A Concert-Video mode is provided for watching music videos and concert footage. The objective is to widen the soundfield of the front speakers, and to bring the vocals up front and center. A Rock Concert mode, in which "a big, powerful sound is reproduced lively and dynamically" imbues contemporary music with "a life-like feeling of thrust and energy," according to the manual. For classical music lovers, the Concert Hall mode attempts to move the center deeply behind the front left and right speakers to create a large-hall ambience. The final mode is Mono Movie, which enhances mono source material to add spaciousness while moving the image forward.

Our first reaction to DSP in audio amplifiers was that it didn't belong. An amplifier, after all, is supposed to recreate sounds accurately, adding a minimum amount of coloration. The purpose of DSP is, by definition, just the opposite.

Our attitude has been changing, albeit slowly. That's mostly because we've heard plenty of processors that sounded bad and downright annoying. But that's far from being the case with the RX-V1050. Although, as with any other digital signal processor, it is possible to add unnatural effects to the audio, we found ourselves listening to a wide variety of music with the DSP turned on! DSP actually *can* add pleasing ambience to everything from Gershwin to Guns'n'Roses.

The receiver provides five output channels, but its outputs actually contain information from seven channels. Along with the left, right, center, and two surround channels, there are left and right DSP channels. The DSP channels are combined with the traditional stereo channels. The amount of the DSP effect that is added is adjustable, however, by a FRONT EFFECT LEVEL control.

To aid in the adjustment of the various DSP settings, the receiver is equipped with a switch that turns the effects on and off. You can also quickly switch between DSP and surround modes both from the remote control and the front panel to choose the mode that best suits what you're listening to. (The names of the various DSP modes, while chosen for sound reasons, may not be consistent with your preferences. We, for example, preferred listening to our rock and roll in the "Hall" mode.)

If you don't find any of the pre-defined modes to be suitable, you can customize them by changing the delay time of the rear-speaker sound. For both Pro-Logic modes, the delay time can be set from 15 to

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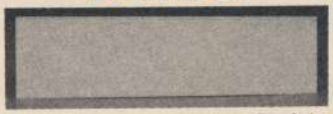

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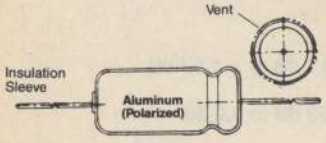

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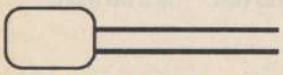

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TEST RESULTS—YAMAHA RX-V1050 AUDIO/VIDEO RECEIVER

The amplifier section of the RX-V1050 is rated to deliver a minimum of 110 watts per channel into an 8-ohm load. Our measurements showed that it could deliver 133 watts to the front left and right channels, and more than 168 watts to the center channel. Those are positive differences of 1.7 and 3.7 dB, respectively. The surround channel was also conservatively rated; we measured 2.3 dB higher than Yamaha's specifications.

The amplifier's dynamic power, that is, its ability to handle musical transients, was measured in our labs at 172.3 watts for the three front channels, and 49 watts for the surround channel. Those also exceeded the manufacturer's specifications by a healthy amount.

The frequency response of the amplifier was measured at the phono input according to the RIAA (Recording Industries Association of America) equalization curves over the audio range. They were also measured at the line-level inputs, and at the main amplifier inputs. (The receiver provides pre-out and main-in terminals) The results are summarized in the table. The −3-dB points were found to be 15.4 Hz and 94 kHz.

The response of the front-, center-, and surround-channel inputs are also shown in the accompanying charts for both the Pro-Logic and the Enhanced Pro-Logic modes. Note that the customized frequency response of the Enhanced mode, which DSP makes possible, would be virtually impossible to duplicate with analog filters.

The tuner-section measurements showed the frequency response to be down about 1.5 dB at the 15-kHz top end of broadcast audio. Although that's not as high as other receivers we've examined recently, it fell right within Yamaha's published specifications. The stereo separation at 1 kHz was measured to be 41 dB as shown in the charts—that's not quite up to the 50-dB specification.

As little as 12.8 dBf of input signal for mono reception, and 37.2 dBf for stereo, was required to achieve 50-dB quieting. The signal-to-noise ration was measured as 73 dB for stereo, 80 dB for mono.

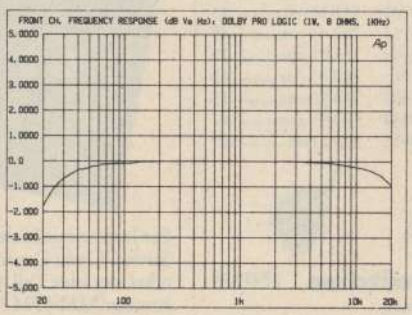
The AM section was poor, as is typical with otherwise high-quality receivers. At 7 kHz, where new standards suggest AM receiver performance should extend to, the response was down 40 dB! Otherwise, the RX-V1050 proved to be a top performer. We would have no hesitation in adding this A/V receiver to our home theater.

TUNER SECTION

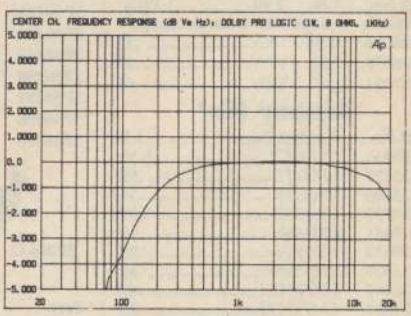
Usable Sensitivity	8.2 dBf
50-dB Quieting Sensitivity	12.8 dBf (mono) 37.2 dBf (stereo)
Stereo Threshold	26.5 dBf
Signal to Noise Ratio	73.0 dB (stereo) 80.0 dB (mono)
Capture Radio	1.3 dB
Distortion (THD + N, 1 kHz)	0.2% (stereo) 0.1% (mono)

AMPLIFIER SECTION

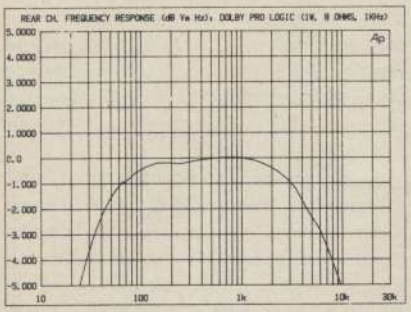
Maximum Power Output (8-ohm load)	
Front	133.2 watts @0.02% THD + N
Surround	39.0 watts @0.15% THD + N
Center	168.4 watts @0.15% THD + N
Dynamic Power (8-ohm load)	
Front	172.3 watts
Surround	49.0 watts
Center	172.3 watts
Frequency Response	
Phono input: (RIAA Equalization)	+0.11 dB to −1.97 dB
Line Level Inputs (20 Hz - 20 kHz)	−1.53 dB to 0.0 dB
Main amp input	−0.06 dB to 0.0 dB
−3 dB points	15.4 Hz and 94 kHz
Channel Separation	
1 kHz	−63.7 dB (left), −66.1 dB (right)
20 kHz	−42.6 dB (left, −39.5 dB (right)



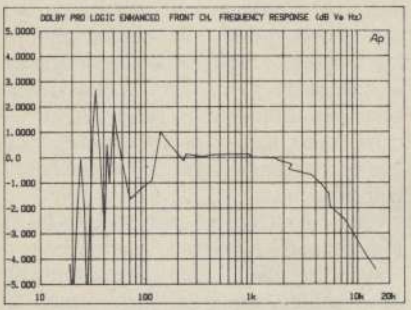
The frequency response of the front channel of the RX-V1050 A/V receiver in the Dolby Pro-Logic mode.



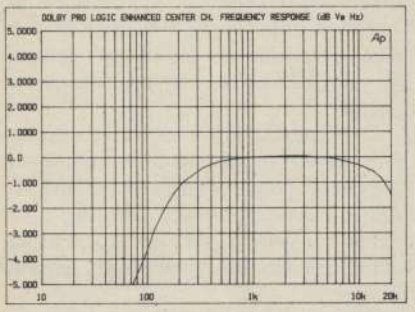
The center-channel frequency response in the Dolby Pro-Logic mode. This is typical of A/V receivers.



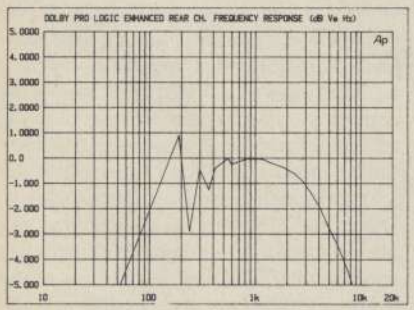
The rear-channel Pro-Logic frequency response. The Dolby specification calls for a roll-off at 7 kHz.



The enhanced-mode front-channel frequency response. Compare this to the standard pro-logic mode.



Frequency response of the center channel in the enhanced-mode. DSP makes such customized responses possible.



The Enhanced-mode rear-channel frequency response.

30 milliseconds. For the other modes, the delay can be set to anywhere from 1 to 100 milliseconds. That extraordinary amount of adjustment makes it possible to create some rather unnatural effects. A solo guitar, for example, can begin to sound like a pair of guitars; we're not sure if that is a good thing.

Most of the important amplifier functions can be handled from the remote control that's supplied with the receiver. The remote can also be taught to control a variety of devices including tape players, a laserdisc player, VCR, and more.

One of the major differences between an A/V receiver and a standard stereo receiver is the ability to route video signals between all of the components of your home-theater system. The RX-V1050 offers a healthy array of video inputs and outputs: laserdisc in, two sets of VCR inputs and outputs, and a monitor out connector. S-video jacks are provided for all connections. Audio inputs include those for connection to a tape deck, a compact-disc player, and a turntable. A set of front-panel auxiliary jacks (located behind a swing-down door) is provided for connecting a camcorder or any other video or audio device.

The RX-V1050 A/V receiver offers a collection of features that are sensible and convenient. The tone-bypass switch is one example. It lets you revert instantly to flat bass and treble settings without changing the setting of the controls.

The receiver also offers 40 station presets. Rather than naming them simply as 1–40, they are stored in five groups (A–E) of eight stations (1–8). That's especially convenient if, for instance, different family members tend to listen to different stations.

The memory locations not only hold the station frequency, but also the mode (stereo or mono). We wish all receivers did the same. Tuning and antenna adjustment are aided by a 13-segment tuning meter.

Recording is made more convenient by an A/V RECORD OUT selector, which lets you record one source on a cassette deck or VCR while listening to or watching another. Other convenience features include a sleep timer and a line-level subwoofer output. A bass-extension mode provides a boost to the low frequencies.

Some people prefer their music straight—no processed sound enhancements in their amplifiers, and no video equipment in their listening rooms. Many more people, according to recent sales trends, find their stereo systems sharing shelf space in the entertainment center with their TV and VCR. Finally, an increasing number of consumers have come to appreciate the effects generated by DSP. Whichever group you fall into, Yamaha's RX-V1050 can handle the job easily. ■

8mm Standard

SONY CCD-TR31 8mm CAMCORDER. From: Sony Corporation of America, 1 Sony Drive, Park Ridge, NJ 07656. Price: $1100.

If you're considering purchasing a camcorder, the odds are that you're thinking about 8mm models. Despite initial projections that the 8mm camcorder format was doomed to failure, it is by far the format of choice for shooting home videos, currently commanding 70 percent of new camcorder sales.

Sony, who invented the 8mm format, often sets the standard for other 8mm manufacturers to follow. Its latest Handycam camcorder, the *CCD-TR31* packs a host of practical features into a small ($7 \times 4\frac{3}{8} \times 4\frac{3}{8}$) and light (1.7 pounds stripped, 2.2 pounds fully loaded with batteries, tape, and shoulder strap) package. Like most of Sony's other camcorders, the CCD-TR31 is easy to use. It's a good camcorder to take a look at if you want to get an idea of where the 8mm format stands today.

One of the most important things to consider when purchasing a camcorder is whether it is easy to use. Once the initial excitement of owning a camcorder wears off, most camcorders find only occasional duty—a friend's wedding, your kid's birthday, the company picnic. All those occasions are ones that you'll want to relax and enjoy; you don't want to spend the entire day fumbling with the camcorder controls. That's why it's important to pay attention to how a camcorder's autoexposure system works.

When it comes to still cameras, we generally want to take manual control over its settings. When it comes to camcorders, we don't feel that way. We prefer to keep our eyes on the action, and let the camcorder take care of the rest.

The CCD-TR31 is the first of Sony's TR-series camcorders to offer a four-program autoexposure control in addition to the standard full-automatic mode. The four modes set the camcorder for special situations with a minimum of trouble. A rotary dial on the side of the unit lets you select the appropriate mode. Portrait mode gives you a narrow depth of field so that the subject is in focus, but potentially distracting objects in the background are out of focus. A Sports mode is intended for shooting fast-moving subjects. For capturing even faster events, such as a golf swing, a High Speed Shutter mode sets the shutter speed to 1/4000 second. That lets you see a clear and sharp picture even when you play it back frame-by-frame. A Twilight Mode is intended to let you capture natural-looking scenes in low-light

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conditions; specifically, you can shoot brightly lit subjects in an otherwise dark scene without increasing the overall gain and ending up with a lot of background noise. The standard Automatic mode is also provided.

Autoexposure modes are a good compromise between the convenience of automatic and the control of manual operation. You get the results you want without a lot of effort.

One situation that often poses problems for videographers is when a subject is backlit with very bright light—say, a skier on a sunny snow-covered slope, or someone in front of a window on a sunny day. Many camcorders offer a backlight function, which opens the lens aperture to properly expose the darker foreground. Sony chose to add automatic backlight compensation. While it makes the camcorder easier to use in most situations, it does remove some control from the user.

An autofocus system is another essential camcorder feature. But unlike autoexposure controls, we often find ourselves taking manual control. That's because autofocus systems have inherent limitations. They generally run into trouble when shooting low-contrast scenes (a cloudless sky, for example), through dirty glass, or when distracting objects are in the foreground.

Like all other camcorders, the CCD-TR31 can be focused manually. Unlike many camcorders, the button that puts the unit into the manual-focus mode is sensibly placed near the lens and easy to use. A small wheel, also at the front of the camcorder near the lens, serves as the focus control. We liked the feel of the control and found it easy to use, even though we prefer traditional focusing-ring arrangements (as found on 35-mm still cameras). We're glad that Sony did not use a power-focus toggle switch or ring as some manufacturers do.

Another must-have camcorder feature is power zoom, even though it's frequently overused and misused by beginners. (Watch any well-produced movie and note how infrequently zooming is used.) The CCD-TR31 offers a two-speed zoom. Pressing the zoom toggle lightly gives you a leisurely zoom; pressing it firmly gives a relatively fast zoom. A somewhat uncommon feature that is included on this camcorder is a zoom meter in the viewfinder that indicates your relative zoom position. The 10× zoom of the camcorder is equivalent to a 45–450 mm zoom lens for a 35-mm still camera. The zoom is handled entirely by optics, not electronically. (Electronic zoom systems can decrease the resultant resolution.)

The CCD-TR31 also features a dual-speed edit-search feature. Edit search lets you check the recorded picture in the viewfinder without entering the playback mode. While you're still in the record mode, a single press of the toggle switch will show the last few seconds of the recorded portion in the viewfinder and returns the camera to the standby mode, ready for the next recording. To go back further, you can press and hold the edit-search toggle. At any point, you can stop and record over a previously recorded scene. That's a procedure you should try to get used to. Although it can't replace video post-production editing, such in-camera editing can greatly reduce the amount of editing that has to be done to end up with a watchable video. The CCD-TR31 does offer a flying erase head, which allows for glitch-free picture transitions. It's a feature worth looking for in any camcorder.

Another way to get good results in-camera is to use the fader that has become a standard feature on virtually all camcorders. Sony adds an interesting twist on the CCD-TR31 fade: Along with the usual sound and picture fade to (or from) black, a digital mosaic effect is offered. The mosaic fade—which produces a picture reminiscent of the effect broadcasters use when they are trying to conceal a subject's identity—added a refreshing touch to our test shots.

Most first-time camcorder purchasers, enthralled by the novelty of shooting home videos, rarely consider that their "masterpieces" will require editing. In reality, forcing someone to watch unedited tape can be considered cruel and unusual punishment. To simplify editing, one feature to look for is a Control-L or LANC (Local Application Control Bus System) control jack. LANC is a standard to which various camcorders, VCR's, and editing controllers conform. LANC allows those devices to "speak the same lingo" for easy, synchronized dubbing and editing. (Not all camcorders that offer a "remote" jack conform to the standard, so be sure to ask before buying!)

The LANC-compatible CCD-TR31 also supports Advanced Synchro Edit, a feature that can be used exclusively with Sony editing equipment such as the EV-S3000 Hi-8 editing VCR reviewed here in our December 1992 issue. In the Advanced Synchro Edit mode, the tape on both the source and recording deck are backed up, and then rolled forward to synchronize them. Interestingly, the owner's manual for the CCD-TR31 does not mention the feature.

One feature that we had never seen before was the built-in lens cover. A flick of a lever either covers or uncovers the lens. No more loose lens cover hanging by a string—or getting lost. We expect to see other manufacturers copy Sony's sensible design.

Like most other 8mm camcorders, the CCD-TR31 is equipped with an infrared remote control. Although a remote can be helpful in some shooting situations—when you want to get into the picture, for example—it's primarily intended for playback. Remember that you can't play back an 8mm tape in a VHS VCR; you must connect your 8mm camcorder to your TV or monitor instead. An easy-to use adapter (an RF modulator) allows you to play back a tape through your TV's antenna input. Direct audio and video connections can also be made to a monitor. (Of course, you can also play back your tape on one of the 8mm VCR's that are becoming increasingly available.) If you're using the remote for recording, you'll appreciate the beeps that confirm recording stop and start. Thankfully, the beep can be turned off.

(Continued on page 20)

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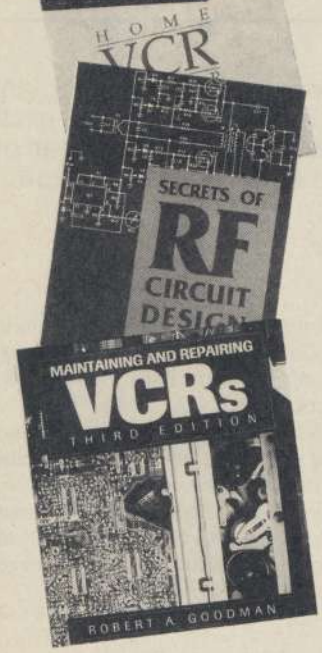

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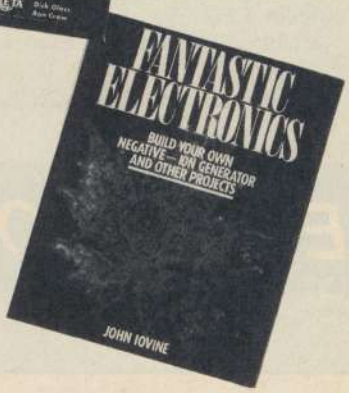

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PE393

SONY CCD-TR31

(Continued from page 18)

Another popular camcorder feature is the ability to record an on-screen indication of the date and time. Although we like the feature, we often forget to turn it on when we start shooting, or we forget to turn it off and end up with the time and date emblazoned on our entire video. Sony's Auto Date feature is a sensible one: Once each day at the beginning of your recording, the date is inserted for 10 seconds. It's also possible to insert the date and time manually.

The camcorder also features a linear time counter that shows the tape position in hours, minutes, and seconds instead of as simple counter numbers. A battery meter in the viewfinder gives you an approximate idea of how much life is left before recharging is necessary. A world clock is also provided; if you travel outside your own time zone, resetting the clock is a simple as changing the "area." On a trip to Europe, for example, you would set the clock to "London" or "Paris."

When it comes to buying any consumer electronics item, you're confronted with a seemingly endless number of models, features, and options. It is quite easy to become totally confused. When comparison shopping, having a "standard" cuts the confusion. If you're shopping for a camcorder, and you've managed to narrow your choices to a mid-range model in the 8mm format, take a close look at Sony's CCD-TR31 Handycam. It offers a host of sensible features, and provides an excellent example of the state of 8mm camcorders today. ■

CORDLESS CHARGER

(Continued from page 13)

permanently mounted recharging bay, takes 1 to 3 hours to recharge the unit with the vehicle's engine running. During recharging using any of the methods, the yellow LED lights. When the unit is fully recharged, the green LED comes on. There's no need to worry about being there as soon as the green LED lights; the unit can remain plugged in indefinitely without overcharging its internal battery. So the Trunk Charger makes a lot of sense.

Cautious motorists—those whose trunks already contain tire-repair kits, a jug of water, a good spare tire, a working jack, replacement belts, jumper cables, a flashlight, a flare, and a complete tool kit—should run right out and buy a Power Charger to add to their peace of mind. And even those motorists who take a more cavalier attitude toward traveling by car might want to carry a little extra "insurance" in the form of the Power Charger. That's particularly true for anyone who has experienced memory lapses when it comes to turning off their headlights or closing their car doors in long-term parking lots. ■

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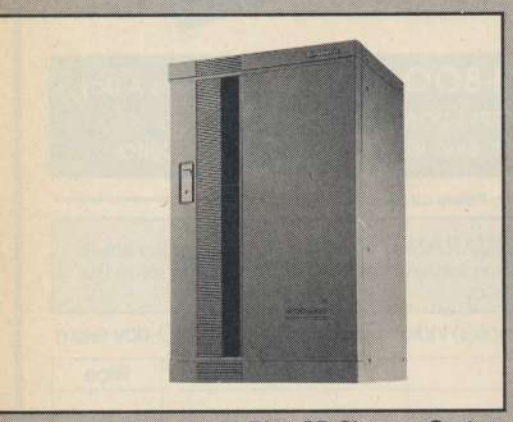

Pioneer 300-Disc CD Changer System

CD Jukebox

Restaurant, shop, and club owners, as well as audiophiles whose CD libraries have outgrown their bookshelves, will appreciate the convenience and storage capacity of the *CAC-V3000* 300-disc autochanger system from Pioneer Laser Entertainment, Inc. (2265 East 220th Street, Long Beach, CA 90810). The system features two playing heads with a built-in cross fader for "zero wait time," which means that there are no silent pauses between selections. The broadcast-quality system can be programmed to play up to nine days of music without interruption. To make programming easy, the system is designed to interface with a wide variety of PC's. Once a library of up to 300 discs is loaded into the CAC-V3000, the operator no longer has to handle the CD's, reducing the chance of lost or damaged discs. Price: N/A.

CIRCLE 55 ON FREE INFORMATION CARD

20 Sherwood Automotive AM/FM/CD Player

Music on the Road

Designed for ease of use, *Sherwood's* (14830 Alondra Blvd., La Mirada, CA 90638) *Model XC-681P* automotive AM/FM/CD player gives the user a "control central" of backlit, logically positioned buttons. CD controls include intro scan, fast forward/reverse, track skip up/down, repeat, shuffle, and program play. The "CompuTuner Plus" tuning system uses a PIN-diode mechanism for consistent, accurate reception, and its "Auto Memory System" automatically stores the local area's strongest signals in memory. Other tuner/amplifier features include 6 AM and 12 FM presets with scan, automatic noise canceler, pulse-noise blanking system, a loudness button, a processor loop, and front and rear preamp outputs for system expansion. Price: $475.

CIRCLE 56 ON FREE INFORMATION CARD

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ELECTRONICS WISH LIST

Hi-8 Stereo Camcorder

The *R-87H* palm-sized Hi-8 hi-fi stereo camcorder from *Ricoh Consumer Products Group* (180 Passaic Avenue, Fairfield, NJ 07004) features an internal rechargeable battery, a variable-speed zoom control, and a quick-connect modular system for fast hookup to a TV or monitor. The 6-volt, lithium-ion type battery, which runs for about 45 minutes at full power, is inserted in the back of the camcorder. It can be recharged in about 45 minutes by placing it in the recharging stand, which connects to an AC outlet. A second, optional, battery can be recharged while the camcorder is in use. Users can control the speed of the zoom (5.9–47.2mm f/1.4) from 1.5 to 16 seconds using a rocker switch. The amount of pressure exerted on the switch controls the speed of the zoom. By placing the camcorder into its quick-connection stand, which requires no cables or power cords, playback of videos on a TV or monitor is a snap. The R-87H also features programmable auto-exposure with three settings: portrait, sports, and high-speed. The camcorder weighs only 20 ounces without the battery or a cassette, and measures just 3.5 × 3.8 × 6.6 inches. Price: $1599.

CIRCLE 57 ON FREE INFORMATION CARD

Ricoh Hi-8 Camcorder

Universal Remote/VCR Programmer

With its full 32K memory, the *Universal Remote/"Quick Set" VCR Programmer (Model 8258)* from *Jasco Products Company* (P.O. Box 466, Oklahoma City, OK 73101) can be used to control virtually any home-entertainment equipment. It is quick to set up, controls as many as eight audio and video devices, and is upgradeable to prevent obsolescence. To make VCR recording easier, the remote poses a series of questions on its LCD. Programming the VCR requires just five quick "answers" to those questions. Price: $99.99.

CIRCLE 58 ON FREE INFORMATION CARD

Cordless Phones

Two cordless phones from *Sanyo* (21350 Lassen Street, Chatsworth, CA 92311-2329) feature "Super Compander III" technology, the third generation of the company's noise-reduction technology. The audio signal is compressed at the base and expanded at the headset, keeping noise outside of audible levels. The *CLT4300* and *CLT4600* both feature a sculpted design, 4096 digital security codes, and backlit handset keypads. The handset's volume level can be adjusted, and its ringer turned on or off. The handset, which can stand upright, also has a 7-day standby feature that allows it to stay away from the base for up to a week before recharging is required. To prevent children (or others) from making toll calls, up to five numbers can be locked out (900-numbers, for instance). In addition, the CLT4600 also adds a keypad and speaker to its base, allowing calls to be made or received from both the base and the handset. Its base also features a ringer on/off control and an LED intercom indicator. Prices: CLT4600, $149.95; CLT4300, $119.99.

CIRCLE 59 ON FREE INFORMATION CARD

Sanyo Cordless Phone

Travel Clock Radio

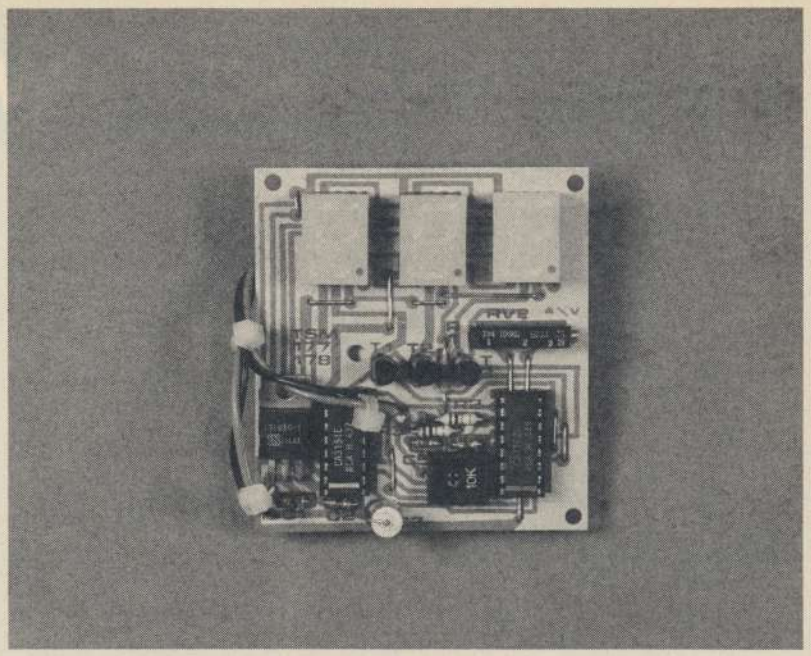
At home, we wake to music, instead of an alarm. When traveling, however, many hotels don't even provide a standard alarm clock, let alone one that includes a radio. *Executive Travelware* (P.O. Box 59387, Chicago, IL 60659) offers travelers the *Flat Pak*, a low-profile AM/FM travel clock radio that measures just 4½ × 3⅛ × 1 inches when closed. With the touch of a button, its black clam-shell case pops open to reveal a large digital LCD time display, angled for easy reading. All controls are also inside. Users can choose to wake to music or to a beeper alarm. Other features include a telescoping whip antenna, a snooze button, and a momentary light to see the time in a dark room. The radio is turned off immediately whenever the clam-shell case is closed. Price: $29.95.

CIRCLE 60 ON FREE INFORMATION CARD

Executive Travelware Clock Radio

A Hands-on Electronics REPORT

TSM 3-Digit DC Voltmeter Kit



CIRCLE 119 ON FREE INFORMATION CARD

A one-hour project that can really dress-up the display of your next project or your car's dashboard.

DC power supplies must be among the most popular and practical projects we hobbyists build. I've made dozens of them myself, but no matter how nice I made each power-supply cabinet, they all looked "home-brewed." I always knew a digital readout would really give them a slicker look, but I thought a readout would either require a lot of parts and assembly time or be prohibitively expensive to buy pre-assembled. I was proven wrong by the TSM 177 3-Digit DC Voltmeter kit, which is both inexpensive and easy-to-build.

Among the meter's specifications are accuracy to 1/10 of a volt, a range from −9.9 to +99.9-volts DC, and a wide power-supply voltage range from 9 to 12 volts DC at 0.5-amps maximum. As we'll discuss later, the design is open to modifications that allow you to expand the range and use of the meter, so these specifications are actually minimal. Let's talk about the basic assembly procedure for the kit before covering those modifications.

Assembly. Building TSM kits is typically very easy, and the voltmeter kit was no exception. For the beginner, there are some helpful soldering hints, pinouts, parts-identification tips, and a color-code chart printed onto the binder of the TSM kit case—indicative of the product line. Of course, if you're a veteran hobbyist you won't need to read them (except maybe to refresh your memory), but it's nice to know TSM is looking out for newcomers to electronics.

Moving on to the instructions, they are very concise and to the point. Instead of a lot of theory, the text describes how to install any component on the board guided by the two-color silk screening. It advises that you connect the components in the order that they are listed in the parts list to avoid any difficulty. That is a particularly useful suggestion because most of the components are taped together to form a strip that places the parts in the order that they appear in the parts list.

I followed the parts list as instructed and things went smoothly. All but one of the components in the strip were in order, so I would just pluck a component from the strip, check the parts list to find out its designation, locate its place on the circuit board, and pop it in. Once all of the components were in place, I soldered them. The whole process took less than a half hour, and should take even an absolute beginner less than an hour.

By the way, the part that was out of order on the strip was an off-board resistor used during a calibration procedure that follows the main assembly. The resistor was placed on the tape close to the other resistors to make taking inventory easier for the builder. The resistor is so obviously out of order that it shouldn't cause anyone trouble.

Once the on-board components were in place, I connected one lead of the off-board resistor (which limits input-signal current) to the appropriate point on the circuit board. Then I attached one wire to the remaining lead of the resistor and another to a grounded solder pad. Those two wires are used as the signal input. I also attached wires to the power-supply inputs. If you wish to run the display off a 9-volt battery, you can attach the appropriate battery clip to those points instead of the wires.

The finished board with the wires was depicted in the assembly instructions for clarity. With all the parts installed and the leads added, the unit was ready for calibration.

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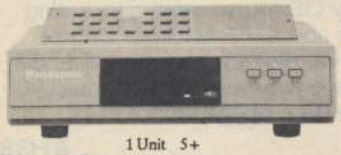

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Calibration and Testing. For testing purposes, I powered the meter off a 9-volt battery. That provided the circuit with a test voltage as well as power. When the battery was first connected the display flickered briefly then went out. As it turns out, that was perfectly normal for the unit, which required some calibration before the display would light continuously.

To calibrate the unit I had to adjust two potentiometers: one to set the zero-volts point of the meter and the other to adjust the scale. To set the zero-volts level, the input wires were connected together (grounding the input) and one of the potentiometers was adjusted till the display lit and showed 0.0.

To adjust the scale you must supply a calibration voltage to the circuit's input. Luckily, you can use the output from a 5-volt regulator on the circuit board for that purpose. With the signal input connected to the regulator's output, I simply adjusted the second potentiometer till the display read 5.0.

As a double check I connected the circuit's input to the 9-volt battery. The display indicated less than the expected 9-volt reading. I took out my multimeter and, sure enough, the battery voltage was low. That was due to the high current draw of the display circuit, which you should keep in mind if you want to run the display off a battery.

Additional Uses. As mentioned earlier, the voltmeter circuit can be modified to go an extra mile. For example, if you wish to include the voltmeter in a project that has its own 5-volt supply, you can leave the 5-volt regulator off the voltmeter circuit board and power it from the main supply. To do that, just run a wire between the pad for the regulator's output pin to the 5-volt source and another wire between the voltmeter ground and the supply ground.

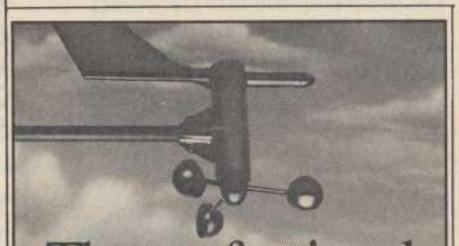
Similarly, if you want to use more than one voltmeter in a project it would be a good idea to use a single regulator to power all the units. That would reduce the amount of power dissipated due to regulation and lower the parts count.

The meter can be used as a current meter as well. To do that you just shunt the meter input with a precision 1-ohm resistor and place the modified meter in the current path. Most of the current will pass through the resistor causing it to develop a voltage drop. The drop will be one volt for each amp that passes. That voltage is detected by the meter and displayed to yield a reading that is equal to the current flow.

The meter need not be limited to DC applications either. By using a full-wave bridge rectifier and filter capacitor at the signal input, you should be able to take reasonably accurate root-mean squared readings of alternating current and voltage.

As should be obvious, a basic building block like the 3-Digit DC Voltmeter could be useful in a number of different projects to perform a variety of tasks. It is easy to build, and only requires a minimum of time to assemble and set.

The TSM 3-Digit DC Voltmeter Kit No. 177 is available from American Design Components (P.O. Box 2601, Secaucus, NJ 07096-2601; Tel. 1-800-776-3700) as item No. 21264 for $34.95. Contact them for further information, or circle No. 119 on the Free Information Card. ■



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PRODUCT TEST REPORTS

Sony STR-D990 FM/AM Audio/Video Stereo Receiver

By Len Feldman

The Sony STR-D990 is a relatively inexpensive receiver that offers a great deal of performance and can serve as the central component in a "home theater" audio/video installation. Few audio/video receivers that we know of offer as many features and as much power for a suggested price of only $480.00 as does this Sony Dolby Pro Logic unit.

A "station index" system associated with the tuner section allows you to divide as many as 30 preset stations into categories such as rock, jazz, etc. Tuning can be done via the presets or by entering the frequency of the desired station directly. In addition, an auto-tuning mode can be used to scan stations automatically, stopping at either all received FM stations or at the strongest signal stations, depending upon the setting of a "tuning level" pushbutton.

CIRCLE 120 ON FREE INFORMATION CARD

The Sony STR-D990 FM/AM audio/video stereo receiver.

In the Dolby Pro Logic or Theater mode, the surround decoder provides the kind of surround sound you experience in Dolby-Stereo equipped motion-picture theaters. Four Dolby operating modes are provided: "normal" (using front left, front right, center channel, rear left and rear right speakers), "phantom" (which omits the center channel speaker), "wide" (used when a full-bandwidth center channel speaker is used) and "3-channel" (when rear or surround speakers are omitted). In addition to the Dolby decoder settings, you can choose six factory preset sound-field environments ("theater," "live," "disco," "simulated (stereo)," and "acoustic." You can also store up to seven settings that you create yourself, manipulating tone settings, delay time for the rear channels, and rear level to suit your own taste. Factory preset or customized sound fields can be linked to specific preset stations or other external audio-program sources.

A multi-function remote control is supplied with the Sony STR-D990 receiver. That unit allows the user to remotely control virtually all of the receiver's functions as well as the functions of equipment that is connected to the receiver.

CONTROLS

The left end of the front panel of the STR-D990 is equipped with the power switch, a speaker-selector switch, and a headphone jack. Nearby are two buttons for audio or video editing. A large display window occupies much of the top section of the front panel, and to its right are cursor-mode indicator lights (tone, index, and surround) and four cursor buttons whose function depends upon the setting of a nearby "cursor-mode" button. This arrangement reduces the number of controls and buttons needed to perform all the control functions of which the receiver is capable. For example, if the cursor-mode button is used to select "tone," the horizontal cursor buttons nearby are used to select bass or treble adjustments, while the vertically pointing cursors either boost or cut the portion of the audio spectrum selected. In the index mode, the cursors are used to select the alphabetic characters used to designate the desired index classification. In the surround mode, the cursor buttons are used to adjust the required time delay.

Below the display area there are various pushbuttons associated with tuning, sound-field selection, and tone defeat. Still lower on the panel are additional numerical buttons, a memory button, the direct-tuning button, an AM/FM band-selector button, an FM-

mode button (stereo or mono), a tape-monitor button, and the program-source selection buttons. At the extreme right of the panel there is the master volume control, a "DFSB" (Dynamic Bass Feedback) button for selecting enhanced bass reproduction (it adds a 12-dB narrow-band boost at around 100 Hz for those listeners who like their bass response "boomy" or "gut shaking"), a balance control, a muting button, and a front-panel set of audio/video inputs that make it convenient to connect a camcorder to the unit.

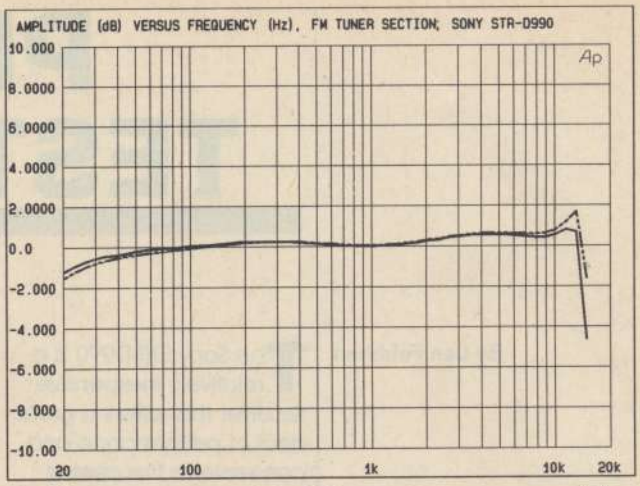
The rear panel of the STR-D990 is equipped with the usual FM and AM antenna terminals (an AM loopstick antenna is supplied for mounting to the receiver); spring-loaded speaker terminals for front-, rear-, and center-channel speakers (two center channel speakers can be used if desired); the required number of audio- and video-input jacks; tape-monitor jacks; a monitor-output jack (for connecting to your TV monitor/receiver); and video- and audio-output jacks to be used for connecting to the inputs of a VCR. Two switched AC convenience outlets are also found on the rear panel as is a grounding terminal for those users who still own and use record turntables.

LAB TEST RESULTS

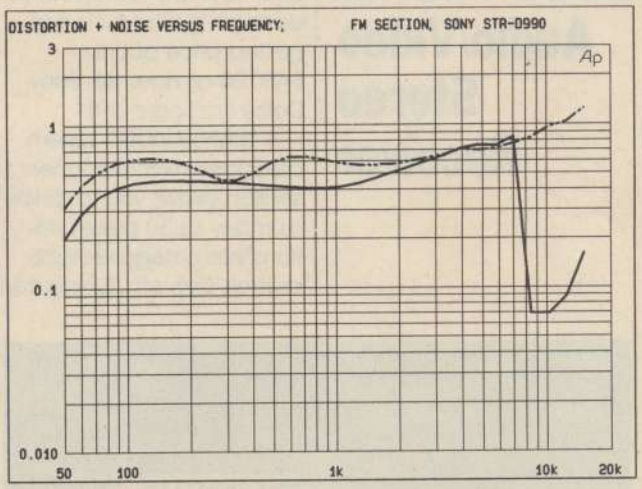
We measured tuner performance first, with the receiver set to the stereo mode. The frequency response of the FM tuner

TEST RESULTS—SONY STR-D990 A/V STEREO RECEIVER

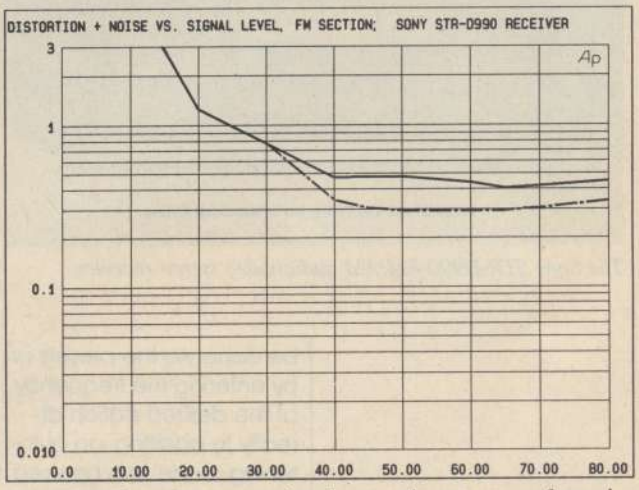
Specification	Manufacturer's Claim	PE Measured
FM-Tuner Section		
Usable sensitivity	11.2 dBf	14.5 dBf
50-dB quieting (mono/stereo)	18.3/38.3 dBf	13.5/34.5 dBf
S/N (mono/stereo)	80/74 dB	76/71.5 dB
THD @ 1 kHz (mono/stereo)	0.3/0.5%	0.4/0.3%
Separation @ 1 kHz	45 dB	44 dB
Freq. response (30Hz–15kHz)	+0,-2 dB	See text
Selectivity	60 dB	62 dB
Capture ratio	1.2 dB	Confirmed
AM Suppression ratio	54 dB	55 dB
Image rejection	70 dB	70 dB
IF rejection	70 dB	72 dB
Spurious rejection	80 dB	85 dB
Amplifier Section		
Power output, 8-ohm loads		
Front (stereo only)	100 W/ch.	Confirmed
Front & center (surround)	65 W/ch.	Confirmed
Surround	25 W/ch.	Confirmed
THD (stereo only)	0.1%	0.095% @ 20 HZ 0.048% @ 1 kHz
S/N, high-level/phono	85/79 dB	80/75 dB
Input sensitivity (high-level/phono)	2.5 mV/200 mV	Confirmed
Tone control range	+/–10 dB @ 100 Hz & 10 kHz	+8,-10 dB
Muting	-20 dB	Confirmed
DFSB (maximum)	+10 dB @ 70 Hz	+10 dB @ 80 Hz
Additional Data		
Power requirements	120V AC, 60 Hz, 240 W	Confirmed
Dimensions (W × H × D, inches)	17 × 5⅞ × 13¾	Confirmed
Weight (lbs/kg)	23 lbs, 2 oz/10.5	Confirmed
Suggested Retail Price:	$480.00	



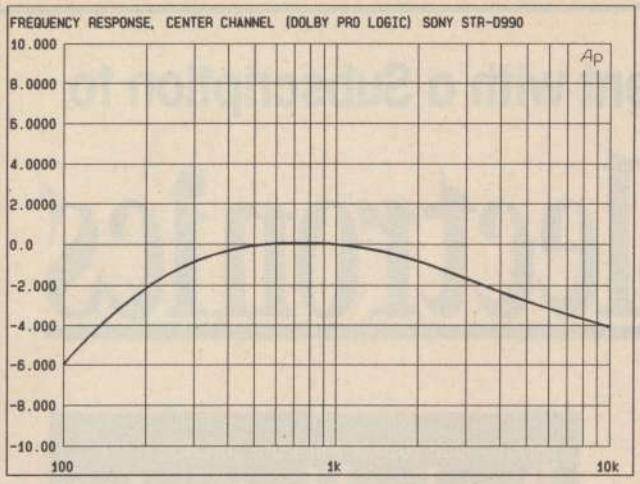
The frequency response of the FM tuner section was essentially flat (within ±1 dB) from 30 Hz to around 13 kHz, and exhibited an attenuation of around 4 dB for the left channel at 15 kHz and less than 2 dB for the right channel.



For mono reception, THD-plus-noise measured 0.4% at 1 kHz, while in stereo, THD-plus-noise was nearly 0.6% for the same modulating frequency.



The THD-plus-noise versus signal-strength test was performed after a lengthy warmup of the receiver. Surprisingly, the stereo THD-plus-noise was actually lower (0.3%) than that of mono, which still measured 0.4%.



The response curve of the center-channel outputs when the surround sound "Normal" Dolby Pro Logic circuitry is used shows marked roll-off at both the bass and treble ends; that is deliberate and is called for by the Dolby Surround system to help emphasize spoken dialog.

section was essentially flat (within ±1 dB) from 30 Hz to around 13 kHz, and exhibited an attenuation of around 4 dB for the left channel at 15 kHz and less than 2 dB for the right channel.

Next we looked at how residual noise varied with signal strength for both mono and stereo incoming signals. In mono, 50-dB quieting was attained with signal levels of only 13.5 dBf, or far better than the 18.3 dBf claimed by Sony. In stereo, 50-dB quieting required an input signal strength of 34.5 dBf, again bettering the claimed specification of 38.3 dBf. The best mono signal-to-noise ratio was 76 dB, while in stereo, S/N reached 71.5 dB for strong signals.

The next test examined how THD-plus-noise varied with frequency. For mono reception, THD-plus-noise measured 0.4% at 1 kHz, while in stereo, THD-plus-noise was nearly 0.6% for the same modulating frequency. We also looked at how THD-plus-noise varied with signal strength. The modulating frequency was a constant 1 kHz. This test was performed after a lengthy warmup of the receiver and, surprisingly, the stereo THD-plus-noise was actually lower (0.3%) than that of mono, which still measured 0.4%.

Next, we measured stereo separation of the FM tuner section. It was excellent, with 44 dB of separation at mid-frequencies, 43 dB at 100 Hz, and just over 30 dB at 10 kHz. It should be noted that in the stereo mode, automatic switching back to mono occurs below signal strengths of approximately 30 dBf.

As is true of so many AM-tuner sections of high-fidelity stereo receivers, the frequency response of the AM tuner section of the Sony STR-D990 was very poor, extending only from around 140 Hz to 2.6 kHz for the -6 dB roll-off points. Despite pleas from AM broadcasters, makers of these receivers continue to treat AM as an afterthought, putting little effort into designing an AM tuner section that can properly reproduce the AM signals being broadcast now by many conscientious AM stations.

Most of the tests we conducted for the amplifier section of this receiver were done in the stereo mode, with surround sound turned off. Under those conditions, the frequency response of the preamplifier/amplifier section was down about 0.3 dB at 20 Hz and about 1.7 dB at 20 kHz. The response was the same regardless of whether measured with the tone controls defeated or in the signal path. We also looked at the response of the center-channel outputs when the surround sound "Normal" Dolby Pro Logic circuitry was used. The response curve of that output showed marked roll-off at both the bass and treble ends; that is deliberate and is called for by the Dolby Surround system. This type of response helps to emphasis spoken dialog, which is what is mainly supposed to emanate from a center-channel speaker. As for the rear or surround speaker amplifiers, we had to judge them strictly with subsequent listening tests, since the time delay introduced for these outputs makes it impossible for our test equipment to properly "track" a frequency response curve.

Reverting to the stereo mode, we looked at how harmonic distortion plus noise varied with frequency when the output was maintained at the rated value of 100 watts/channel with both channels driven. At mid-frequencies, THD plus noise was only 0.048%, and even at 20 Hz distortion remained within the 0.1% limit specified by Sony. We were able to repeat that test for the center channel, using the "Normal" Dolby Pro Logic mode while maintaining a regulated output of 65

(Continued on page 81)

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ELECTROMAGNETIC FIELDS and your HEALTH

BY JOHN IOVINE

Learn why there is so much concern over low-level low-frequency electromagnetic radiaton, and build a simple device that can detect that radiation in your home.

There is a growing concern over possible health hazards from low-frequency electromagnetic fields. When the story first broke, the fields of greatest concern were those given off by overhead power-line transformers.

At the time, the reasoning was unless you worked in the electronics field or lived in close proximity to power lines, you could consider yourself unaffected and relatively safe. New evidence suggests that that really isn't the case. It appears that the ELF (extremely low-frequency) magnetic fields given off by many household appliances and computer monitors can be of sufficient strength to be considered potentially hazardous.

For those of us who dabble in electronics, or earn our livelihood in electronics or a related field, the concern becomes more prominent. That being the case you should be aware of what research has taken place and what's been reported thus far. If after reading the following material you feel the concern to be legitimate, you can construct a simple ELF monitor to check and modify your environment. The ELF monitor described later in this article is simple to build and should cost less than $25.

Why Worry Now? You might be wondering if ELF radiation is such a health hazard, why has it taken so long for anyone to mention its dangers? To answer that question, we must look at how scientists first sized-up the potential harm of low-frequency magnetic fields.

To begin with, it was originally believed that weak low-frequency fields could not have a significant impact on living systems. This belief was based on the amount of thermal energy the ELF fields could produce in biological tissue. The energy produced by ELF radiation is much smaller than the normal thermal energy internally generated by a cell's metabolic processes. In addition, the quantum energy of the fields is far too low to break any chemical or nuclear bonds in the tissue. Therefore, scientists felt DNA would be safe from mutating. Finally the electric field of the body is much greater than the induced field from ELF radiation. Looking at all these factors, it's easy to understand why the scientific community quickly dismissed epidemological studies that indicated a statistically significant hazard associated with ELF radiation.

As a result, the scientific community has of late been portrayed in the press as a bunch of hacks or bureaucratic puppets genuflecting for grants from government agencies and power companies. However, the reason for the quick dismissal was one of genuine disbelief, not a mass cover up. Although in truth, a few scientists have stepped over the line and maligned good researchers based upon the profit and loss statements of their employers. These scientists are few in number and the entire scientific community should not be condemned based upon their isolated unethical endeavors.

The Real Deal. Although the mechanism by which ELF fields affect biological tissue is still not exactly known, it has been unequivocally shown that cells *are* affected. The best research to date shows that a cell's membrane, or receptor molecules in the membrane, are sensitive to extremely weak low-frequency magnetic fields.

Some of the effects reported so far include changes in the flow of ionic compounds through cellular membranes. Also noted are changes in DNA synthesis, RNA transcription, and the response of cells to signaling molecules such as hormones and neurotransmitters. In addition, changes have been noted in the kinetics of some cellular biochemical reactions.

Not all ELF radiation produces all of those effects, it's more complex than that. Some effects are only noted at discrete frequencies and amplitudes of the magnetic field. Others depend on the strength and orientation of an ambient constant magnetic field. Still others require a threshold of exposure time rather than field strength.

The inherent danger or increased likelihood of various forms of cancer due to ELF radiation has been emphasized in the press. As stated pre-

viously, the quantum energy of these fields isn't sufficient to produce any type of chromosomal damage. Simply, that means that ELF radiation doesn't initiate cancer. The increased incidence of cancers is due to the fact that ELF radiation can promote the disease after the cancer has been triggered by another agent. The cancer is promoted because ELF radiation can suppress the body's immune system. In addition, it has been determined that at the cellular level the ELF fields increase the production of the enzyme ornithine decarboxylase, which has been cited to support the promotion of cancer in the body.

The Evidence As studies progress, more information will be forthcoming. Here is a short list of reported events that indicates the potential hazards of ELF fields:

- In 1972, Soviet researchers linked electromagnetic fields with low-grade health problems such as fatigue and headaches.
- In 1977, Robert Becker, physician and biophysicist Andrew Marino testified before the New York State Public Service Commission about the results of their experiment that showed negative health effects due to exposure to ELF fields.
- In 1979, Nancy Wertheimer an epidemiologist and physicist Ed Leeper published a study that showed a statistical link between childhood cancers and the proximity of certain types of high-current power lines to the home.
- In 1982, a Washington State study examined the data for the deaths of 438,000 workers in the State occurring between 1950 and 1979. The results of the study showed that leukemia deaths were elevated in 10 out of 11 occupations where the workers were exposed to ELF fields.
- In 1986, Dr. Bernard Tribukait, a professor of radiobiology at the Karolinska Institute in Stockholm Sweden, reported that the fetuses of mice exposed to sawtooth electromagnetic fields had a greater incidence of congenital malformation than unexposed mice. The sawtooth waveform is a typical waveform generated by monitors and TV's.
- In 1988, the Maryland Department of Health and Hygiene found an usually high rate of fatal brain cancer among men employed in electrical occupations.
- In 1989, John Hopkins University found an elevated risk of all cancers among New York Telephone Company cable splicers.
- In 1990, David Savitz, an epidemiologist at the University of North Carolina, determined through a study that pregnant women who used electric blankets have children who have a 30% increased risk of cancer as compared to children whose mothers didn't use electric blankets.

So far I have concentrated on the negative effects of 60-Hz ELF fields. But you should know that there are positive medical uses for ELF fields. Robert Becker had discovered that ELF fields when appropriately applied (at a specific frequency and amplitude) can promote healing and therapeutic responses in tissue. The ELF fields appear to be a double-edged sword, being able to heal as well as harm.

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Computer Monitors. Concern over the radiation from televisions and computer monitors (which are closely related in operation and technology) is nothing new. A number of years ago there was concern as to whether radiation given off by color televisions could have a negative impact on health. This concern was based primarily on ionizing radiation, (low-level X-rays) whose intensity fell off dramatically a few inches away from the TV screen, and turned out to be incidental. But more insidious than this overt threat is one that has passed unnoticed until quite recently: the low-frequency magnetic fields generated by the coils on the TV's CRT (Cathode-Ray Tube).

Computer monitors (or VDT's, which stands for video-display terminals) generate these low-frequency magnetic fields, which emanate in all directions, too. They present a greater hazard than TV's because a user must sit closer to them during use. In fact, there have been numerous reports from female computer operators of cluster miscarriages. The word cluster refers to a greater-than-average incident of miscarriages among a group of women.

The latest study on cluster miscarriages was performed in 1988 by doctors Marilyn Goldhaber, Michael Polen, and Robert Hiat of the Kaiser Permanente Health Group in Oakland, California. The study involved 1,583 pregnant women. The results of the study showed that female workers who used computers more than 20 hours a week had double the miscarriage rate as female workers who did similar work without computers.

What the study didn't take into account, but which I'm sure will be studied in the near future, is the incidence of malformations and cancers in the children born to women who use computers as compared to the children of women who don't. If we extrapolate the information from David Savitz's 1990 study, we may see another side to the problem.

Excessive ELF fields emitted by computer monitors is an industry-wide problem, virtually all CRT computer monitors emit excessive ELF radiation unless specifically stated otherwise. Recently, *MacWorld Magazine* (in the July, 1990 issue) did ELF studies on 10 popular monitors. All of the monitors tested emitted excessive ELF radiation at close range. The only recommendation that they or I can offer you at this time is to increase the distance between you and the monitor. A working distance of two feet is recommended.

The ELF field propagates from all points around the monitor, not just from the front screen. That fact becomes important in offices where computer terminals are in close proximity to one another, because workers can be exposed not only from their own monitor, but also from a neighbor's monitor.

It's important to realize that the ELF field given off will vary somewhat from monitor to monitor. Table 1 summarizes some measurements I took of

the 60-Hz ELF field from my 1084 Amiga monitor. As you can see, the ELF field strength drops off dramatically with distance from the monitor. (I could not check the ELF radiating from the bottom of the monitor because of the way it is situated in my work space.)

TABLE 1—MONITOR RADIATION

Distance (Inches)	Intensity (Milligauss)				
	Front	L-Side	R-Side	Back	Top
0	78	97	90	125	270
4	24	14	16	37	65
12	5	1.5	1.5	8	9
24	<1	<1	<1	3	1.5

Shielding. It would be nice if we could purchase a radiation shield for our monitors, similar to the antiglare shield on the market. Unfortunately none exist. Be very careful, there are some antiglare screens on the market that make a claim of blocking the electric and magnetic fields given off from the monitor. First, electric fields as far as I know have not been reported to have any negative impact upon health. Second, the magnetic field the screens claim to block are in fact the visible-light frequency fields generated by the CRT. Those high-frequency magnetic fields have not been shown to have a negative impact on health. These antiglare screens have no impact on the low-frequency (60-Hz) magnetic fields that I am talking about.

There is no easy way to shield the monitor to reduce the propagating ELF field. I have tried a number of different methods, none had any appreciable impact on the ELF radiation. The best recommendation is too keep the monitor 18–24 inches away from yourself.

Another possibility is to use an alternative type computer monitor. Liquid-crystal display (LCD) and plasma-display monitors do not emit ELF fields. However, their drawbacks are higher cost and lower resolution.

Precautions Around the Home. There are sources of ELF around the typical home. Before I discuss them, I would first like to explain a little bit about dose-rate. An appliance in the home may generate a very strong ELF field, but if the appliance is only used a short time, its risk factor is probably low. (Note the word "probably" in the last sentence; currently, exact data on short-duration high-strength fields hasn't been gathered.)

Electric razors fall into this category. Line-operated (plugged into a wall socket rather than battery-powered) razors do produce extremely strong ELF fields, and are held in very close proximity to the body, but because they are only used for a short time, the total exposure or dose is small and they are probably safe. In contrast to the electric razor is the electric blanket. It emits a much lower ELF field strength, but for a much longer exposure time.

Dr. Nancy Wertheimer, who first published the epidemiological study showing a correlation between 60-Hz power lines and the increased incidence of childhood cancer in this country, has also performed similar research on users of electric blankets. She has found that there is a higher incidence of miscarriages among pregnant women who use electric blankets as compared to pregnant women who do not.

For users of electric blankets, the following recommendations can be made. One, switch to ordinary blankets. If you like electric blankets, use one to heat your bed before going to sleep, but unplug the blanket before you actually get into bed. It is not sufficient to just turn off the blanket because many blankets still produce an ELF field as long as they're plugged into a socket.

Fluorescent lights are much more efficient (more light per electrical watt) than ordinary incandescent bulbs. Because of that, they have become the standard lighting system used in most offices, industry, and now around the home. However, fluorescent lights require a ballast transformer that generates an ELF field. If you're using a small fluorescent lamp as a desk light, you may want to consider switching to an incandescent lamp, which generates virtually no ELF.

That also applies to the new energy-saver fluorescent lamps that replace standard incandescent bulbs. They are okay for overhead lighting, but you may want to reconsider using them for close-up work or desk lighting.

Television sets fall into the same category as our computer monitors. Like our monitors, they produce a field that propagates from around the entire set. The ELF field will propagate through standard building materials such as wood and plaster. So if a TV set is placed against a wall, the ELF will propagate through the wall into the adjoining room. So it becomes important not to place a bed against a wall with a TV set on the other side.

The small motors in AC-powered clocks also produce ELF fields. If the clock is an alarm clock that lies close to the sleeper's head, it could be giving that person a significant dose of ELF radiation during the night. The recommendation would be to move the clock a significant distance away. Or purchase either a battery-powered clock or a digital clock that produces a negligible field.

Hair dryers fall in the same category as electric shavers since using them means short-term, high field-strength exposure. They are probably safe for most people. Notable exceptions are people who use them in their occupation, such as hair stylists and hair dressers.

Electric baseboard heaters are another potential problem appliance. A minimum of 4 feet of distance is recommended from such heaters.

It's impossible for me to state what a safe, long-term dose rate is because it hasn't been established. Effects have been reported at dose rates as low as 1.2 to 3 milligauss. So I would venture to say try to limit long-term exposure to 1 milligauss or less.

Bottom Line. A controversy still rages as to the impact and extent of ELF fields on human health. However, I feel there is sufficient evidence for we hobbyists (especially since we dally with electronics) to take a conservative view on the amount of exposure we should allow ourselves. I would try to limit long-term exposure to one milligauss or less. Of course, its

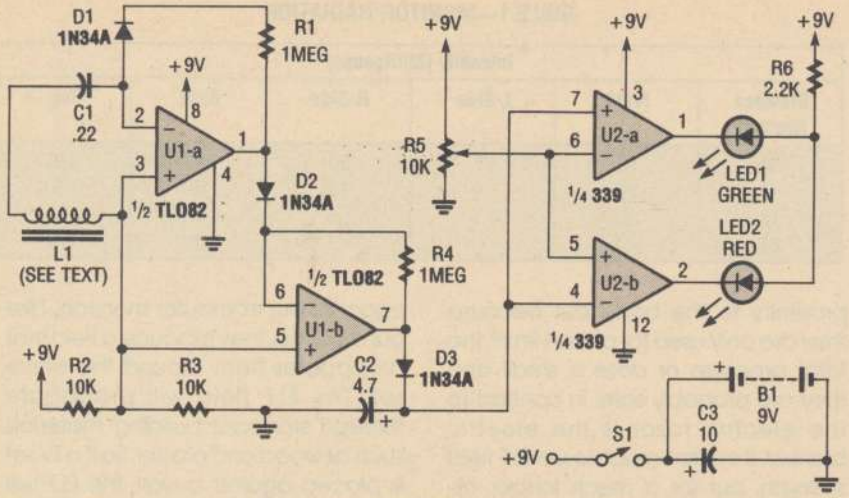


Fig. 1. The sensing coil (L1) for the ELF Monitor is really a telephone pick-up coil normally used to monitor phone calls. Any 60-Hz hum picked-up by the coil is rectified, amplified, and then used to charge a capacitor.

difficult to know what your ELF exposure level is without a milligauss meter.

That's where the ELF Monitor described in this article comes in. It senses the 60-Hz magnetic field from any appliance and indicates whether the radiation level is safe or not. The warning trip point of the circuit is about 1.5 to 2.5 milligauss. Using the meter around your home, apartment, or work space will enable you to identify potentially hazardous ELF fields and their sources so you can implement corrective action. If you decided not to build the meter, I'd advise you to at least follow the precautions outlined above, as they will help you to reduce exposure.

The Monitor Circuit. The key to the ELF Monitor circuit (see Fig. 1) is the ELF sensor. The sensor—a telephone pick-up coil normally used to record phone conversations—detects any 60-Hz magnetic field and produces a voltage in proportion to its strength. That simple sensor doesn't have the sensitivity of more expensive sensors, but it is sufficient to build a simple low-cost go/no-go ELF monitor.

The circuit uses a dual-biFET op-amp. A germanium diode (D1) in the feedback loop of the first stage provides non-linear feedback. The diode allows the op-amp to amplify and rectify small signals from the sensor. When there is insufficient output voltage from the op-amp to drive the diode into conduction, the feedback loop is open and the op-amp operates at its full voltage gain. At this point only a small voltage from the ELF sensor is required to produce a large output. The large output drives the diode into conduction at which point resistor R1 determines the amplifier's gain.

In practice, the millivolt-level AC signal from the sensor is put through a half-wave rectifying op-amp amplifier, where D1 compensates for the voltage drop across diode D2. The second half of the op-amp then provides additional amplification of the signal so it is sufficient to drive the two LM339 comparators, which are used as display drivers.

I chose to use germanium diodes for D1–D3 since they have a lower voltage drop (about 0.3 volts) than silicon diodes and extract superior performance from the op-amps. The PC-mounted potentiometer (R5) allows the unit to be calibrated (as described later). Capacitor C1 is used to block DC that may flow from resistor R2 through the coil.

PARTS LIST FOR THE ELF MONITOR

SEMICONDUCTORS

U1—TL082 dual BiFET op-amp, integrated circuit
U2—LM339 quad comparator, integrated circuit
D1–D3—1N34A small-signal germanium diode
LED1—Green subminiature light-emitting diode
LED2—Red subminiature light-emitting diode

RESISTORS

(All fixed resistors are ¼-watt, 5% units)
R1, R4—1-megohm
R2, R3— 10,000-ohm
R5—10,000-ohm PC-mount micro-potentiometer
R6—2200-ohm

ADDITIONAL PARTS AND MATERIALS

B1—9-volt transistor-radio battery
C1—0.22-µF Mylar capacitor
C2—4.7-µF, 16-WVDC, electrolytic capacitor
C3—10-µF, 16-WVDC, electrolytic capacitor
L1—Telephone pick-up coil (Radio Shack No. 44-533B)
S1—SPST toggle switch
Plastic case, 9-volt battery clip, 9-volt battery holder, LED holders, perfboard, hot-melt glue or epoxy, solder, etc.

Construction. There are a few construction tips worth mentioning for building the ELF Monitor. First of all, you should use a non-conductive plastic case such as the one mentioned in the Parts List. A metal case will impede any measurements. You can assemble and solder components on a small piece of perfboard. However, keep all lead lengths as short as possible to minimize stray pickup in the wiring.

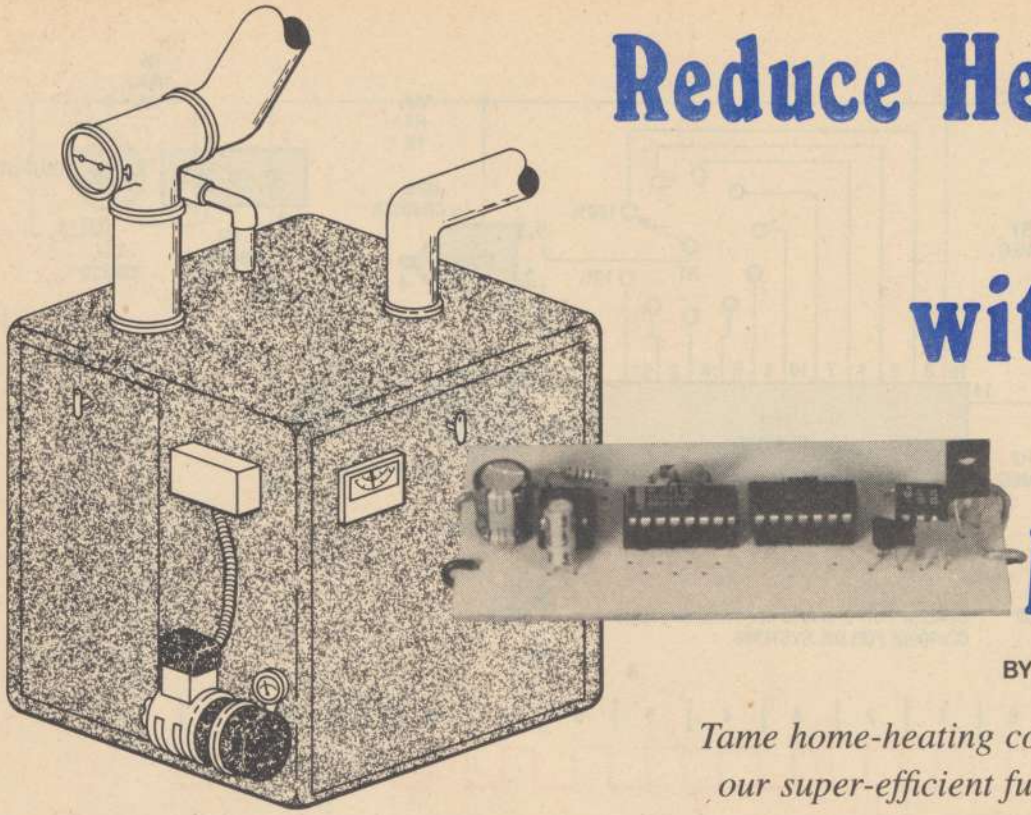
Once the main circuit is completed, you will have to connect it to the pick-up coil. The coil has some shielded cable protruding from its side. Cut this cable off leaving about 3 inches attached to the coil. Split and strip the wires in the cable. Attach the pick-up coil to the front of a plastic case using epoxy or hot glue.

The top of the case must be drilled to accommodate the two LED's and the power switch. You will also have to arrange a suitable mounting scheme for the battery.

Calibration must take place in an area that is relatively free of 60-Hz radiation. Turn on the monitor and adjust R5 so that the green LED is just about to turn off and the red LED is about to turn on. That's the proper operating point.

The monitor quickly detects an ELF field, however it is a little sluggish (typically, there is a delay of around 1 second) in responding once the field is removed.

(Continued on page 85)



Reduce Heating Costs with the Fuel Miser

BY ANTHONY J. CARISTI

Tame home-heating costs by installing our super-efficient furnace controller

The price of everything is steadily going up these days. And one of the major drags on most household budgets is home heating costs; be it gas, oil, or electric. That's because a properly designed heating system operates with a 100% duty cycle, meaning that the burner is either 100% on—producing possibly 80,000 to 120,000 BTU's of heat energy for each hour of operation—or 100% off at any given time. Unfortunately, there is a flaw in that type of operation; the thermostat knows nothing of the amount of heat that has built up in the heat exchanger, which can transfer just so many BTU's of heat. Thus, the burner can run and run until the temperature set-point is reached, and so a great amount of heat is simply wasted. Not a very efficient method of operation, to say the least.

Some thermostats have a "heat anticipator" feature that shuts off the burner before the thermostat set-point temperature is reached. That helps somewhat; but a significant amount of heat (fuel) is still wasted. Of course, there are other ways to reduce heating-fuel consumption; installing better insulation and/or lowering the thermostat settings, for instance. But what can be done after those measures have been taken?

That's where the *Fuel Miser* described in this article comes into play. The Fuel Miser, which is designed to be connected to the thermostat circuit of a heating system, takes control of the system and meters out a selected amount of fuel, as we'll soon see.

How It Works. The Fuel Miser, a solid-state, optically isolated, duty-cycle controller, is connected in series with the thermostat wiring of a heating system. Without regard to the thermostat setting, the Fuel Miser allows the furnace burner to operate at selectable duty cycle increments of 10% of up to 100%. There is no apparent loss of comfort level because the Fuel Miser, while keeping the burner cut off, allows the heat normally trapped and wasted in the exchanger to be distributed, thereby enhancing fuel efficiency.

Gas- and electric-heating systems respond well to short bursts of fuel demand. For gas- and electric-heating systems, the Fuel Miser is designed so that each 10% of duty-cycle time is just 45 seconds, and a complete on-off cycle takes 450 seconds or 7½ minutes. Oil systems are more restrictive in their cycling requirements because the system must be allowed time to cool down before it can be restarted. For oil systems, the Fuel Miser's duty cycle is 3½ minutes for each 10% increment of duty cycle, thus a full on-off cycle (100% duty cycle) takes 35 minutes.

The Fuel Miser's duty cycle is set by a specific value of timing capacitor—one value for gas and electric systems and another for oil-fired systems. The circuit's duty cycle is instantly adjustable at any time by means of a 10-position rotary switch. An optoisolator/Triac circuit is used to interface the Fuel Miser to the heating system.

About the Circuit. Refer to the schematic and timing diagrams in Fig. 1. In the schematic diagram (Fig. 1A), U1 (a 555 oscillator/timer) is configured as an astable multivibrator (or free-running oscillator), whose operating frequency is determined by R1, R2, and C2. The value of C2 (the timing capacitor) must be selected for the type of fuel used by the system; gas, electric, or oil. For gas and electric systems, U1's operating frequency should be to 0.02 Hz; for oil systems, it should be set to 0.005 Hz.

The output of U1 at pin 3 is fed to the clock input of U2 (a CD4017B decade counter/divider with 10 decoded outputs) at pin 14. That causes U2 to advance one count for each low-to-

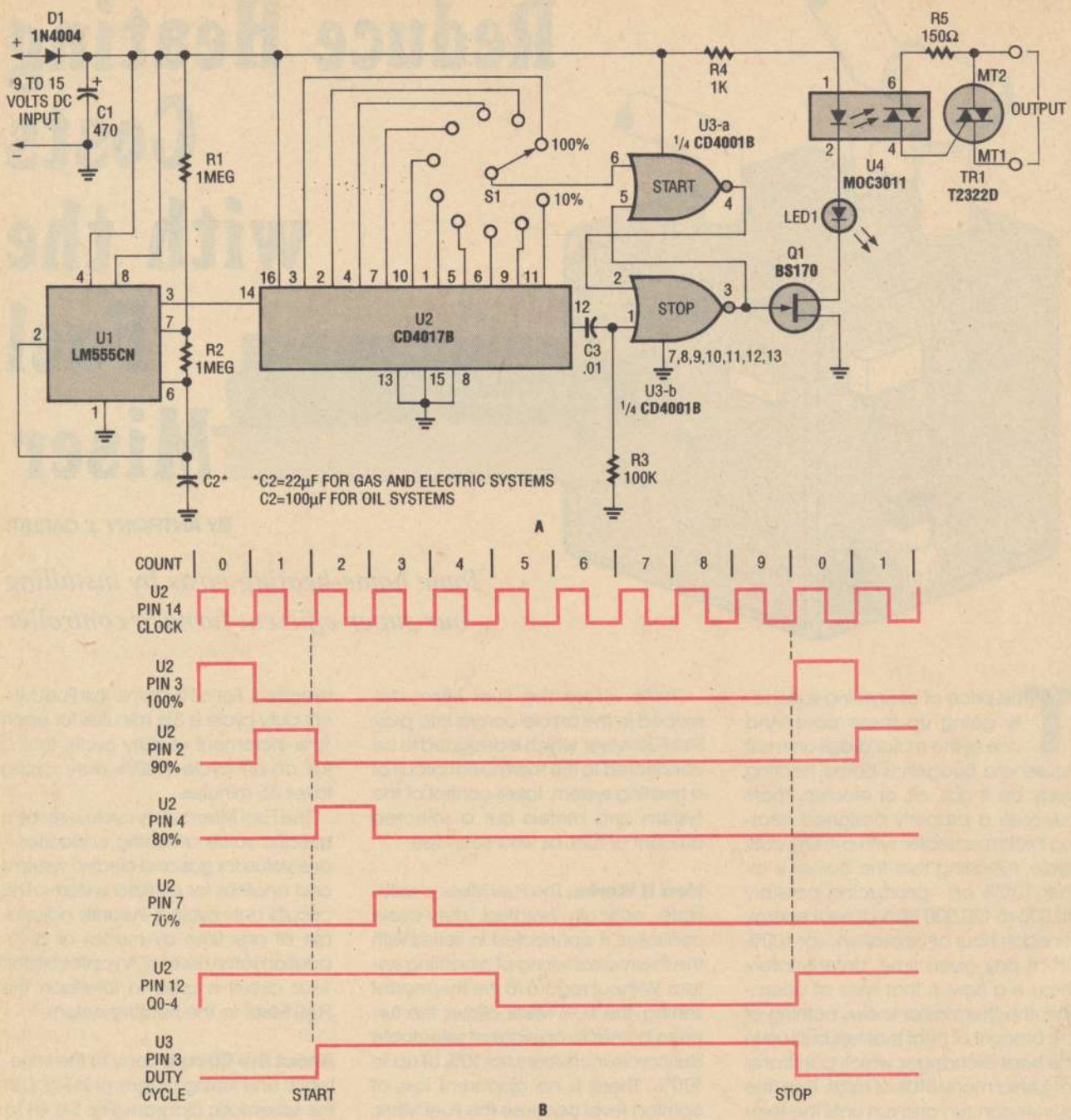


Fig. 1. Here are the schematic and timing diagrams for the Fuel Miser. The Fuel Miser is comprised of a 555 oscillator/timer (U1), a CD4017B decade counter/divider (U2), half of a CD4001 quad two-input NOR gate (U3), an MOC3011 optoisolator/coupler (U4), a BS170 N-channel, enhancement, TMOS field-effect transistor (Q1), a T2322D Triac, and a handful of support components.

high transition of the clock input, sequentially forcing one of U2's ten outputs high, as illustrated in Fig. 1B.

An eleventh output at pin 12 (the carry output) goes high when output pins 3, 2, 4, 7, and 10 (the 0, 1, 2, 3, and 4 counts, respectively) go high. When U2's outputs at pins 1, 5, 6, 9, and 11 (which correspond to counts 5–9, respectively) go high, pin 12 goes low. The output of U2 at pin 12 is fed to one input (pin 1) of a bistable latch, comprised of U3-a and U3-b (½ of a CD4001 quad two-input NAND gate). The U2 output selected via S1 is fed to the other input of the latch at pin 6. Together, those two U2 outputs are used to start (set) and stop (reset) the latch, which in turn determines the duty cycle of the circuit.

Now, let's assume that S2 is set to the 80% duty-cycle (U2 pin 4). When pin 4 (which corresponds to a count of 2) goes high, the latch sets, causing its output at pin 3 to go high and pin 4 to go low. The latch remains in that state until U2 goes from count 9 to count 0.

At that point, a positive-going signal appears at pin 12 of U2 and is applied to pin 1 of U3, causing the latch to reset. The latch remains in the reset state until U2 again reaches a count of 2, and the cycle repeats.

Note that the output signal appearing at U3 pin 3 has a duty cycle of 80%, which is the setting selected by S1. One can see that if S1 is set to any of the other nine decoded outputs of U2, the resulting duty cycle at U3 pin 3 will respond accordingly.

The signal appearing at U3 pin 3 is used to bias Q1 (a BS170 N-channel, enhancement, TMOS field-effect transistor) on and off. The drain of Q1 is connected through LED1 to the cathode end of U4's internal LED. When Q1 turns on, current flows through U4 (an MOC3011 optoisolator/coupler), causing LED1 to light and U4's Triac-driver output stage to turn on. With U4 activated, the Triac-driver applies gate current to TR1 (a T2322D), causing it to conduct. At that point, operating power is fed through the thermostat wiring of the heating system, permitting the burner to operate (provided that the thermostat is calling for heat).

When the signal at U3 pin 3 is low, Q1 is cut off and no current flows into U4, so TR1 remains off and the heating-system burner is prevented from operating during the off-time of the Fuel Miser. However, heat continues to flow from the heat exchanger into the system, maintaining the comfort level, without consuming fuel.

The Fuel Miser can be set to 100% duty cycle at any time; that restores the heating system to its normal operating state. When S1 is set to any of the other positions, the circuit provides a fuel savings that depends on the selected duty cycle.

The Fuel Miser can be powered from any 9–15-volt DC power source (although the author's unit was powered from a common wall adapter). Any ripple voltage generated by the power source is filtered out by C1. Diode D1 is included in the circuit to protect against accidental reverse polarity connections.

Construction. There is nothing critical about the construction of the Fuel Miser. In fact, if you choose, the circuit can be built on perfboard using point-to-point wiring techniques.

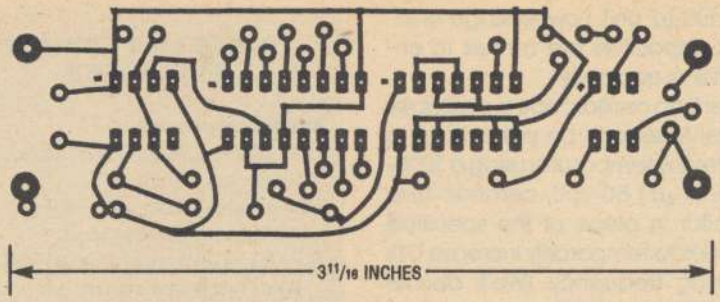


Fig. 2. The author's prototype was built on a small printed-circuit board, measuring about 3 11/16 by 1 3/4 inches; a full-size template of that printed-circuit pattern is shown here. You can etch your own board from the pattern shown or purchase one from the supplier listed in the Parts List.

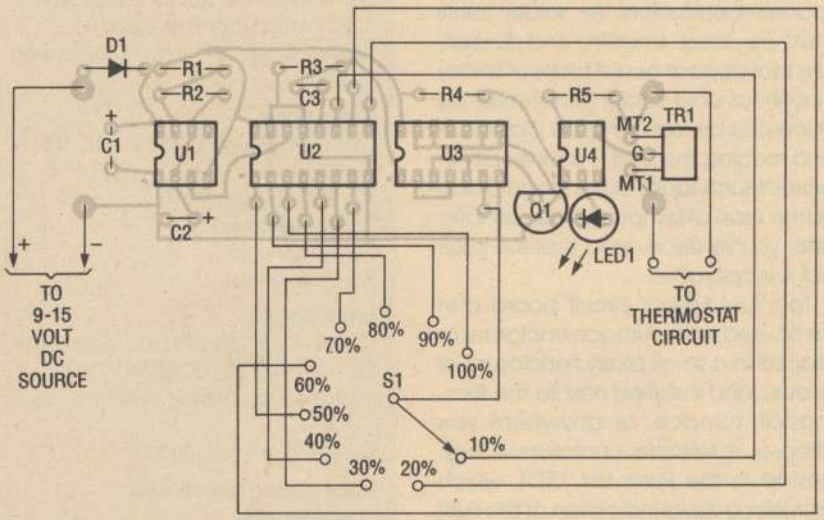


Fig. 3. Assemble the printed-circuit board using this parts-placement diagram as a guide. Note: It is recommended that sockets be provided for all of the IC's.

However, the author's prototype was built on a small printed-circuit board, measuring about 3 11/16 by 1 3/4 inches; a full-size template of that printed-circuit pattern is shown in Fig. 2. You can etch your own board from the pattern shown or purchase one from the supplier listed in the Parts List.

Once you've obtained all the necessary parts and the printed-circuit board, construction can begin. Assemble the printed-circuit board using Fig. 3 as a guide. It is recommended that sockets be provided for all of the IC's. The use of sockets allows for ease of troubleshooting and servicing of the circuit should it ever become necessary. If you do not have 6- or 8-pin sockets on hand (for U4 and U1, respectively), they can be simultaneously fabricated by carefully cutting a 14 pin socket into two pieces with a small hacksaw.

After the sockets are installed, place and solder all the passive components (resistors, capacitors), except the timing capacitor (C2). Follow the passive components with the active components. Be sure that all of the polarized components (electrolytic capacitors and all semiconductor devices) are properly oriented; all it takes is one misoriented polarized part to render the circuit inoperative. That error can also cause parts to be damaged.

Timing-Capacitor Selection. As mentioned earlier, the Fuel Miser's timing circuit (U1) must be set for the type of fuel—gas and electric or oil—that is used by the heating system. It does not matter what kind of heat is produced by the system . . . hot water, warm air, or steam . . . the Fuel Miser will operate properly when the correct value of timing capacitor (C2) is installed. For gas (either propane or natural gas) and electric systems, make C2 a 22-μF unit. For oil burners,

use a 100-μF unit. Low-leakage electrolytic capacitors are a must to ensure timing accuracy.

Note: If an oscilloscope is available, the Fuel Miser can be put through a rapid test by temporarily using a 1000-pF (0.001-μF) 50-volt, ceramic-disc capacitor in place of the specified C2 values to temporarily increase U1's oscillating frequency. (We'll discuss the rapid test procedure later.)

Final Assembly. When the board is fully populated (excluding C2), inspect it carefully for any possible shorts, especially between closely spaced conductors. All solder joints must be shiny, smooth, and filleted. Any that appear as dull blobs of solder (known as cold solder joints) must be corrected by removing the old solder and redoing the joint. It is far easier to correct such faults at this stage of the game than attempting to do so later after you've discovered that the project is inoperative.

The Fuel Miser's circuit board can be housed in the furnace enclosure or placed in a small plastic enclosure of its own, and installed next to the thermostat, furnace, or anywhere you choose. A suitable enclosure is suggested in the Parts List. LED1, which provides a visual indication of the Fuel Miser's operation may optionally be placed on the front of the cabinet or furnace where it can be seen.

The rotary switch may be installed in any convenient location near the circuit board, with the positions marked 10%, 20%, etc., (in 10% increments) up to 100%. That allows you to instantly change the Fuel Miser's duty cycle at any time. When wiring S1 refer to Fig. 3, which illustrates the location of the connections.

Power for the author's prototype was provided by a 9–15-volt DC wall adapter (but any power supply with an output voltage within the specified range will do just fine). Be sure to check your power source with a DC voltmeter to be sure that its output voltage is within the specified range. Connections between the power supply and the Fuel Miser can be hard wired, or made through a miniature plug and jack arrangement. In any case, be sure to observe proper polarity.

When installing the Fuel Miser in a cabinet, a pair of binding posts or a two-wire connector should be used to bring TR1's MT1 and MT2 terminal connections out to the heating system. The polarity of those wires does not matter. Once those terminals are installed, **do not** connect the Fuel Miser to the heating system until instructed to do so, which will come later, after the checkout procedure.

PARTS LIST FOR THE FUEL MISER

SEMICONDUCTORS

U1—LM555CN oscillator/timer, integrated circuit
U2—CD4017B decade counter/divider, integrated circuit
U3—CD4001B quad 2-input NOR gate, integrated circuit
U4—MOC3011 optoisolator/coupler with Triac-driver output, integrated circuit
Q1—BS170 N-channel, TMOS enhancement-mode FET
TR1—T2322D 4-amp, 400-PIV Triac
D1—1N4004 or similar 1-amp, 400-PIV silicon rectifier diode
LED1—2-volt, 20-mA, light-emitting diode

RESISTORS

(All fixed resistors are ¼-watt, 5% units.)
R1, R2—1-megohm
R3—100,000-ohm
R4—1000-ohm
R5—150-ohm

CAPACITORS

C1—470-μF, 25-WVDC, electrolytic
C2—22- or 100-μF, 25-WVDC, electrolytic (timing capacitor, see text)
C3—0.01-μF, ceramic-disc

ADDITIONAL PARTS AND MATERIALS

S1—SP10T rotary switch (RS 275-1385 or similar)
Printed-circuit board materials, enclosure (RS 270-231 or similar), IC sockets, binding posts, 9- to 15-volt DC, 20 mA or more, wall adapter (RS 273-1431 or similar) wire, solder, hardware, etc.

Note: The following parts are available from A. Caristi, 69 White Pond Rd., Waldwick, NJ 07463: PC board for $10.95; U1, U2, U3, U4 for $2.25 each; Q1 for $2.00; Q2 for $3.50; C2 low-leakage capacitor (specify value) for $1.50. Please add $3.00 postage/handling to all orders.

Checkout. Since the Fuel Miser's timing circuit operates at a very low frequency (0.02 Hz for gas and electric systems and 0.005 Hz for oil systems), a DMM or VOM with an input impedance of 1 megohm or more and a clock or stopwatch can be used to checkout the circuit. If, on the other hand, an oscilloscope is available, a more rapid checkout procedure can be performed by temporarily substituting, as mentioned previously, a 1000-pF capacitor for C2 and observing the output waveform's duty cycle. In addition, if a 24-volt step-down transformer is available, it can be used to check the Triac output of the circuit.

Begin the checkout procedure by connecting a 9–15-volt DC power source to the circuit, and after making sure that the source voltage is properly polarized, apply power. Check the signal at pin 3 of U1. A normal indication is about a 67% duty cycle (high level ⅔ of the time and low level ⅓ of the time). The period of the signal should be about 45 seconds (gas/electric systems) or 3½ minutes (oil systems) with the specified value of C2 installed. With a 1000-pF unit installed, the period (as observed on the oscilloscope) should be about 2 milliseconds.

If you do not obtain the correct signal at U1 pin 3, troubleshoot the circuit before proceeding. Check the power supply voltage and its polarity. Check the orientation of D1, U1, U2, and C2. Check the values of R12, R2, and C2. If everything looks correct, try a new 555 oscillator/timer (U1).

Set S1 to the 50% position, and observe LED1 or examine the scope display of the signal at pin 3 of U3. After the circuit has gone through one on-off cycle, the duty cycle should, thereafter, be 50%. With the specified value of C2 for gas and electric or oil systems in place, the off and on times of the LED should be either 3¾ minutes or 17½ minutes each, depending upon which timing capacitor has been installed in the circuit. With the 1000-pF test capacitor installed, the off/on times should be 10 milliseconds each.

Try different positions of S1, and verify that the duty cycle can be set from 10% to 100% (in increments of 10%) by observing LED1 and/or the scope display of the signal at U3 pin 3. If the LED

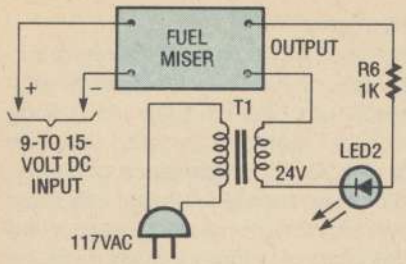


Fig. 4. When the circuit is working properly, the output circuitry can be checked using a 24-volt step-down transformer, a 1k resistor, and an LED. Together those components simulate the load that the Fuel Miser sees during normal operation.

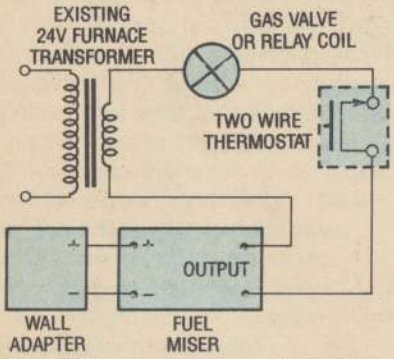


Fig. 5. This drawing shows the Fuel Miser connected in series with the thermostat of a two-wire gas furnace that's powered by a 24-volt transformer.

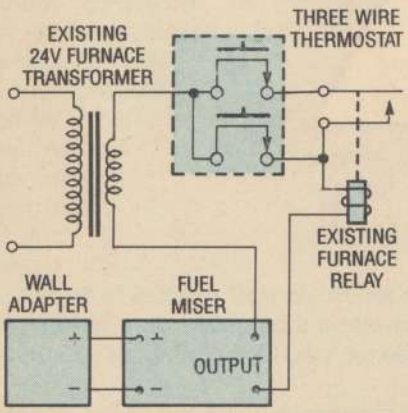


Fig. 6. Some oil-fired systems use three-wire thermostats to control the operation of the burner motor and ignition system by activating a relay. This is a typical installation for such systems.

does not flash on and off as indicated or the duty cycle is incorrect, check the orientation of U2, U3, U4, Q1, and LED1. Check C3, R3, and R4. Check the wiring to S1. Examine the circuit board carefully for any possible shorts, opens, or cold solder joints. Try new chips for U2, U3, and U4.

When the circuit is working properly, the output circuitry can be checked using a 24-volt step-down transformer, a 1k resistor, and an LED as illustrated in Fig. 4. Together those components simulate the load that the Fuel Miser sees during normal operation. Before making this test, however, install the correct C2 value (assuming that the rapid test was performed).

With power applied to the circuit and the 24-volt transformer energized, allow the Fuel Miser one on-off cycle to initialize itself. Then verify that the test LED flashes off and on at the duty cycle set by S1, and that it's synchronized with LED1. Check that the total time for one complete cycle (off and on) of the test LED is either 7½ minutes for gas and electric systems, or 35 minutes for oil systems for any setting of S1.

If the test LED does not light, check the orientation of TR1 and the wiring associated with it. Also check R5 and/or try another optoisolator/coupler for U4 and/or another Triac For TR1.

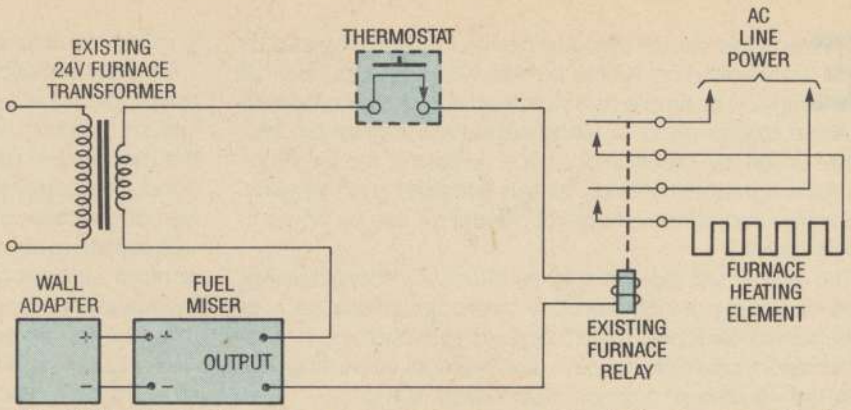


Fig. 7. Electric-heating systems may or may not use a relay in the thermostat circuit. Those that do have a relay can be controlled by the Fuel Miser by wiring its output circuit in series with the relay coil connections as shown here.

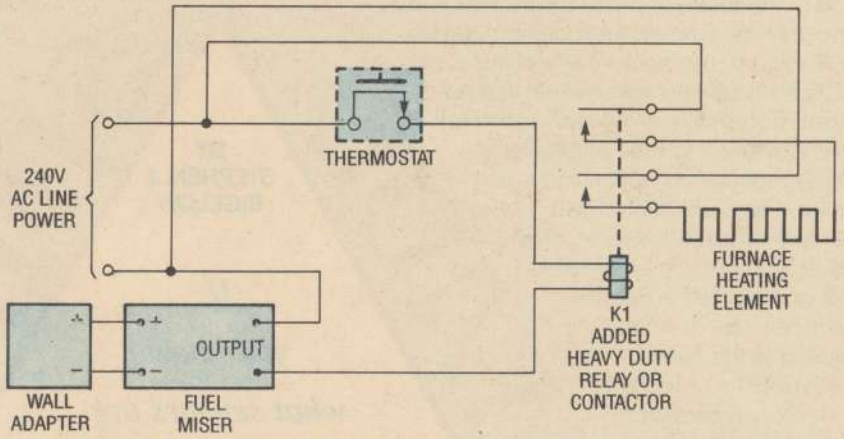


Fig. 8. Electric-heating systems that do not contain a low-current thermostat (as in the previous installation), use a heavy-duty thermostat that directly feeds current to the heating element.For such systems, it will be necessary to install a heavy-duty relay (K1 in this example) to control the heavy heating-element current.

Installation. As previously stated, the Fuel Miser can be installed directly into the furnace enclosure, on the wall next to the thermostat, or in any desired location where the thermostat wiring is accessible. Be sure to turn off power to the furnace before attempting the installation.

Figure 5 shows the Fuel Miser connected in series with the thermostat of a two-wire gas furnace that's powered by a 24-volt transformer that is located inside the furnace enclosure. The polarity of the connections from the Fuel Miser to the furnace circuit is not important. The thermostat directly controls the gas valve, which operates at 24-volts AC and draws about 1-ampere of current. The Triac in the Fuel Miser switches current off and on in the thermostat circuit.

Three-wire thermostats are used in some oil-burner systems to control the operation of the burner motor and ignition system (by activating a relay).

(Continued on page 93)

SENSORS MADE SIMPLE

BY STEPHEN J. BIGELOW

If you know what sensors are available to you, you are more likely to develop projects with a lot more capability.

Electronic circuits depend heavily on input devices for information about the outside world. An input device may be as simple as a switch or magnetic sensor, or as intricate as an optical or ultrasonic sensor. Sensors are typically driven by mechanical force, pressure, temperature, position, light, and sound. Sensors translate such physical quantities into either voltage or current for use by an electronic circuit.

This article will explain the construction, characteristics, and operation of commercially available sensors such as mechanical switches, magnetic switches, photocells, phototransistors, and optocouplers. For the more interesting sensors, we will present a simple application or two.

Mechanical Switches. Switches in which an external mechanical force actuates a set of electrical contacts to complete or break a connection are probably the simplest form of input device available. In a momentary switch, the connection is made or broken when the mechanical force is removed and the contacts return to their original position. A maintained switch may use similar electrical-contact sets, but the connection will remain after the actuating force is removed until another force (usually in the opposite direction), is applied to the switch.

Pushbutton, toggle, and rotary-type switches may be either momentary or maintained. As you probably know, there are momentary and maintained versions of each different type of switch available in a large selection of sizes, shapes, and ratings to suit many different applications.

There is one type of mechanical switch that deserves special mention as it is readily used as a sensor: the microswitch. A microswitch is ideally suited as a sensor to detect physical limits and position. It can be mounted in any position using regular screws.

All of the types of switches mentioned can be separated into two general categories: commercial and industrial. Commercial switches are used for light-duty, low-current applications in homes and offices, or any other environment that is reasonably dry, clean, free of dust and harmful vapors, and protected from vibration and high impact forces. Radios, televisions, and computers typically make use of commercial-grade switches.

An industrial switch usually handles heavier current (over 5 amps), and is built to withstand constant abuse from shock and vibration. Many industrial switches are sealed to resist the dust, dirt, oils, chemicals, and harsh solvents that are present in many industrial environments.

Contact corrosion and electrical arcing are the two greatest problems with mechanical switches. Gold, silver, palladium, platinum, molybdenum, and tungsten are among the most widely used contact materials because they can conduct electricity very well. Yet, in the presence of an oxygen atmosphere, each of these metals will eventually react with oxygen to form a layer of poorly conducting oxide on the contact surfaces. This oxidizing phenomenon will degrade the reliability of the switch since a good electrical contact may not be formed each time the switch is activated.

Arcing, on the other hand, is caused when switch contacts must handle high currents. Each time a heavily loaded switch closes, electrons jump the gap between contacts before a good connection is formed. When an arc occurs, a minute amount of metal is deposited from one contact to another. The size of the deposit depends on the current that is being switched—greater current results in a greater arc, and a faster breakdown of the contact surfaces. Over time, arcing will cause gaps and pits in the contacts, which will eventually ruin the switch. Table 1 (see page 44) lists some of the characteristics of common contact materials and their susceptibility to arcing and oxidation.

There is another problem that must be considered when using switches in high-speed circuits, such as a computer interface. Most switch contacts will not make a perfect contact right away. A mechanical switch can take up to 10 milliseconds for the contact surfaces to settle together and form a low-resistance connection. During this time, mechanical noise (or "bounce") can cause unpredictable operation.

A switch de-bounce circuit, such as the one in Fig. 1, can be used to overcome that problem. The circuit effectively ignores the bounce to provide a clean digital output signal. The feedback from one side of the inverting gate to another will cause a brief delay before the digital output can change. That delay will usually be enough for most bounce to settle. When the output of U1-b finally changes, the output will be a single, clean change in logic level. It is usually a good idea to de-bounce any switch input that will be used to drive a digital input, or in any other sensitive application where noisy contacts can cause erroneous operation.

Flex Switches. A flex switch, as shown in Fig. 2, can be used to sense touch or strain. The switch can be actuated by pressing on it with a certain amount of force, or bending it.

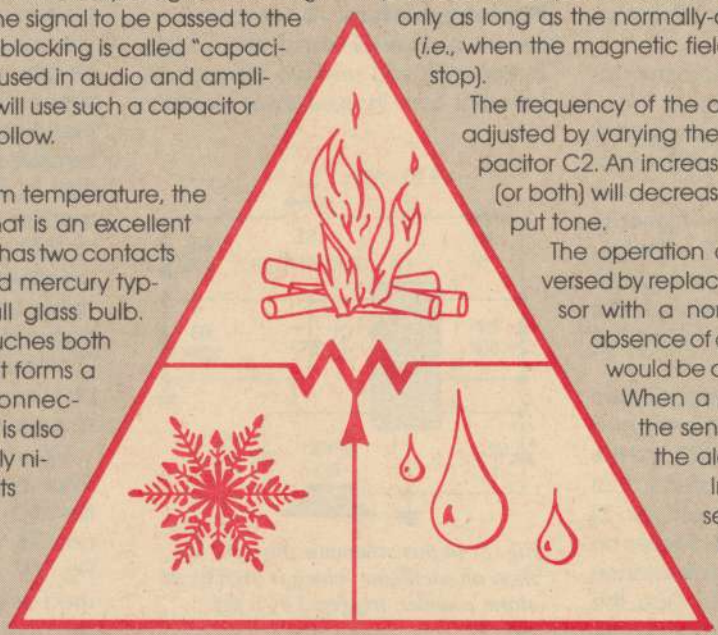
They are generally sealed to keep out moisture and oils. Flex switches are well suited as weight sensors, "part-in-place" detectors, and as alarm-system triggers.

The touch alarm shown in Fig. 3 uses a flex switch as the sensing element. When the remote switch is flexed, stepped on, or pressed with sufficient force, the contacts will close and enable the 555 timer tone-generator circuit. The frequency of the tone output depends on the value of resistor R4, and capacitor C2. To increase the frequency of the output tone, decrease the value of R4 or C2 (or both).

The tone will sound for some amount of time after the flex switch is released. The on time will depend on the value of resistor R3, and capacitor C1. To lengthen the duration of the tone when the switch is released, increase the value of R3 or C1 (or both).

By the way, the speaker capacitor (C3) is needed to block any DC that may be present in the output signal, allowing only the AC component of the signal to be passed to the speaker. That method of DC blocking is called "capacitive coupling" and is widely used in audio and amplifier applications. In fact, we will use such a capacitor in many of the circuits that follow.

Mercury Switches. At room temperature, the metal mercury is a liquid that is an excellent conductor. A mercury switch has two contacts and a small amount of liquid mercury typically housed inside a small glass bulb. When the liquid mercury touches both contacts at the same time, it forms a low-resistance electrical connection between them. The bulb is also filled with an inert gas (usually nitrogen) that not only inhibits contact arcing, but also prevents oxides from forming on the contact leads. As a result, a mercury switch may be cycled on and off almost indefinitely without a failure.



The drawback to a mercury switch, however, is that it is delicate. The glass bulb can easily shatter if it is subjected to any real impact forces. It should also be pointed out that mercury is a poison that can be readily absorbed through the skin causing sickness and death. Use caution when mounting mercury bulbs. A miniature pan mounted in an enclosure below the bulb is a good idea as it may be able to catch any mercury that may escape in the event of a bulb fracture.

The circuit of Fig. 4 has such a switch used as a simplified tilt sensor. As long as the bulb is held slightly below the horizontal, its contacts will remain open, and the pull-down resistor (R2) will pull the inverter input to a logic 0 state. The inverter will output a logic 1, which will prevent current from flowing in the LED, so the LED will not light.

If the mercury bulb should tilt above the horizontal, liquid mercury will flow back and complete the circuit. So 5 volts will appear on the inverter input, driving its output to a logic 0 state. Current will then flow through the LED and it will light to indicate a tilt (or non-horizontal) condition. The mercury switch itself could also be substituted for the flex switch in Fig. 3 to create an audible tilt alarm.

Magnetic Proximity Sensors. A magnetic proximity sensor detects the presence of any magnetic object that moves within its sensing range and generates a switch closure. A plain magnet is typically used as the actuator for these switches. Proximity sensors are available in the normally-open (the switch is off when the magnet is withdrawn and turns on when the magnet is applied) and the normally-closed (the switch is on when the magnet is withdrawn and turns off when the magnet is applied) models to accommodate various applications.

An audible magnetic-field sensor circuit is shown in Fig. 5. Note that the circuit is very similar to the one used in the tone-alarm that was shown back in Fig. 3. In this circuit a switching mechanism is used to enable a tone output from a 555 timer. Almost any magnetic field that is brought close enough to the proximity switch will be enough to actuate the alarm and produce an output tone. The circuit will generate a tone only as long as the normally-open switch is held closed (*i.e.*, when the magnetic field is removed, the tone will stop).

The frequency of the output signal can be easily adjusted by varying the value of resistor R3 or capacitor C2. An increase in the values of R3 or C2 (or both) will decrease the frequency of the output tone.

The operation of the circuit could be reversed by replacing the normally-open sensor with a normally-closed one. In the absence of a magnetic field, the sensor would be on and a tone would sound. When a magnetic field is applied, the sensor contacts will open and the alarm will stop.

In many alarm systems a sensor is placed over a door, with the actuating magnet mounted in the door itself. As long as the door remains closed, the magnet will hold the proximity sensor open and the alarm will remain off. If the door is opened, the magnet moves away, allowing the sensor to turn on and sound the alarm.

Switches are ideal for sensing applications that detect only closed and open conditions, but in many situations, the sensor must be able to generate an output that is proportional to the physical condition being measured. Optical sensors suit this purpose perfectly, so let's discuss them.

Photocells. A photoconductive cell (typically called a photoresistor) is a two-lead semiconductor device whose resistance will vary with the amount of incident light striking its surface. Cadmium-sulfide (CdS) is the most common semiconductor material used in photocells. Its sensitivity is very similar to that of the human eye. Cadmium-selenide (CdSe) is also used, but it has a slightly different response to light than cadmium sulfide.

Photocells are relatively slow devices. A CdSe sensor may need up to 10 milliseconds to respond to a change in light, while a CdS cell may take as much as 100 milliseconds to settle after light input changes. That slow response makes them difficult to interface to digital circuits directly, but photocells are remarkably sensitive to small variations in ambient

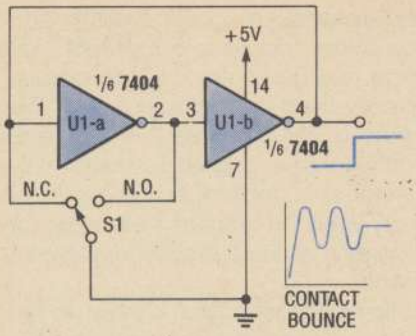


Fig. 1. This debounce circuit will keep the electrical noise generated by the mechanical switch (S1) from reaching the next circuit in line.

light, making them very easy to use as analog light detectors.

The resistance of a photocell depends upon its particular construction. It's dark resistance (the resistance measured with all illumination removed) is usually very high—on the order of 1 megohm or higher (5 megohms is not unusual). The light resistance (the resistance measured across the leads of the sensor when it is fully illuminated) may fall below 250 ohms for some devices.

Figure 6 contains a photocell used to control the output frequency of a 555 timer. The resistance of R2 and the CdS cell form a voltage divider that feeds the control-voltage pin (pin 5) of the timer. As the light increases on the surface of the sensor, its resistance will decrease. That will reduce the control voltage on pin 5, and the output frequency at pin 3 will increase. The base frequency of the oscillator is set by the resistor (R3) ana capacitor (C2).

The frequency range of the circuit depends on the value of R2. If R2 is very small relative to the light resistance of the sensor, the cell will have a great effect on the frequency. If R2 is very large relative to the dark resistance of the sensor, the frequency range may be limited. As a rule of thumb, choose a value for R2 that is mid-way between the light and dark resistance of the sensor.

By reversing the locations of the CdS photocell and R2, the operation of the voltage divider will be reversed, and output frequency will decrease as more light shines on the CdS cell. Photocells are used extensively in light meters and other analog circuitry, but their slow response time can sometimes be a problem where light intensity changes quickly. For a faster response time, a phototransistor is used.

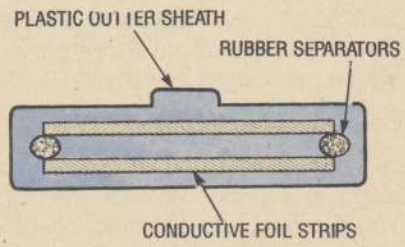


Fig. 2. This is a cross-sectional diagram of a flex switch. They can be used as pushbuttons or even position sensors.

Phototransistors. All semiconductors have a certain sensitivity to light, therefore if you remove the actual transistor from its case, it will react to

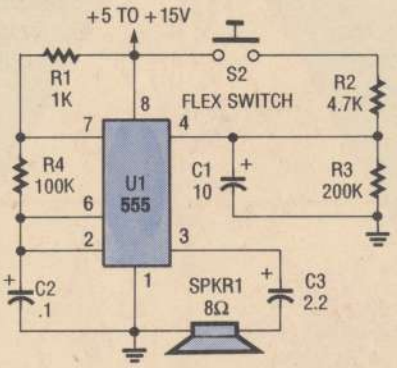


Fig. 3. In this schematic diagram we show an oscillator, which is used as an alarm sounder, triggered by a flex switch.

light. Photons of incident light that strike the base region will liberate free electrons and generate a small amount of current flow.

A phototransistor is an optical sensor that is specially designed to take advantage of this phenomenon. The base region of a phototransistor is very much larger than the base of a typical bipolar transistor and its case has a window that allows light to enter. Usually, only the collector and emitter leads are available from a phototransistor. The window is typically a clear mica or quartz lens in the top of the device.

Phototransistors are typically NPN devices built from selenium, silicon, or germanium. Each of those semiconductor materials have an optimum response in a different portion of the electromagnetic spectrum. Selenium

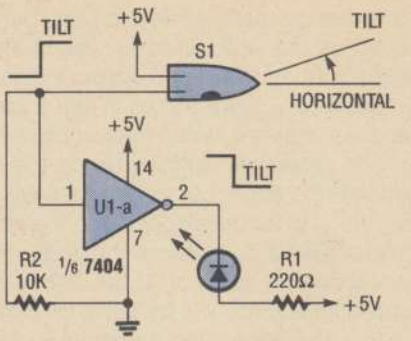


Fig. 4. If the mercury bulb in this circuit is tipped, U1-a will light LED1 by going low indicating a "tilted" condition.

phototransistors work well in the visible portion of the optical spectrum. They are sensitive to most of the wavelengths of light the human eye responds to. Silicon devices will work in the visible range, but they are most sensitive to wavelengths above visible light in the near-infrared area. Germanium phototransistors will respond to light over a very broad range of wavelengths (which include those of visible light), but their peak sensitivity occurs in the very far infrared region. Phototransistors are much faster than photocells, with typical response times as low as 1 microsecond.

Like many transistors, a phototransistor may be operated as an amplifier or as a switch, as shown in Fig. 7A and 7B, respectively. In the circuit of Fig. 7A, a VT9012 phototransistor is used as an adjustable optical sensor. The phototransistor (Q1) will remain in an off, or non-conducting state as long as light is absent. While Q1 is off, the 2N2222A driver transistor (Q2) and the 12-volt relay will be off.

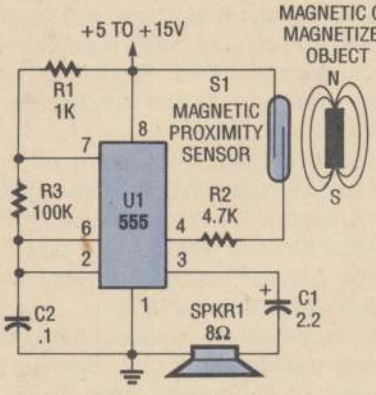


Fig. 5. This circuit is similar to the circuit back in Fig. 3. However this circuit is activated by a reed switch and sounds an alarm as long as the contacts are closed.

As light is applied to the sensor, it will begin to conduct, and the voltage drop across the sensitivity-adjustment resistor (R1) will rise. When this voltage drop becomes high enough, the driver transistor (Q2) will turn on and activate the 12-volt relay. The setting of R1 will determine the turn-on point for the driver transistor. If illumination is removed, Q2 will shut down and turn off the relay.

In order to reverse the operation of the circuit, you must reverse the positions of Q1 and R1 as shown in Fig. 7B. In that circuit, Q1 will not conduct in darkness, and the voltage drop across it will activate Q2. This, in turn, will keep the 12-volt relay on. When light is applied to the phototransistor, it

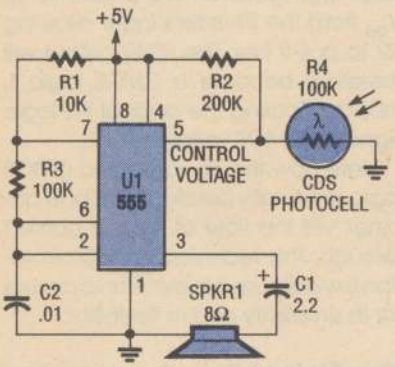


Fig. 6. The frequency of this light-controlled oscillator is determined by the amount of illumination experienced by the light-dependent resistor, R4.

will begin to conduct. Increasing the light will gradually decrease the voltage across Q1. If enough light is available, there will not be enough voltage across Q1 to keep Q2 turned on. Driver transistor Q2 will then shut down and release the relay. Again, the turn-off point for Q2 is determined by the setting of R1.

Infrared Emitters. Infrared emitters are little more than light-emitting diodes designed to generate optical energy in the infrared (IR) region of the electromagnetic spectrum. When the infrared LED is forward-biased, electrons move through a specially formulated semiconductor junction in the LED, causing it to give off energy in the form of photons. The amount of energy emitted by the IR LED is directly proportional to the current flowing through it. There are two common wavelengths that are created by IR

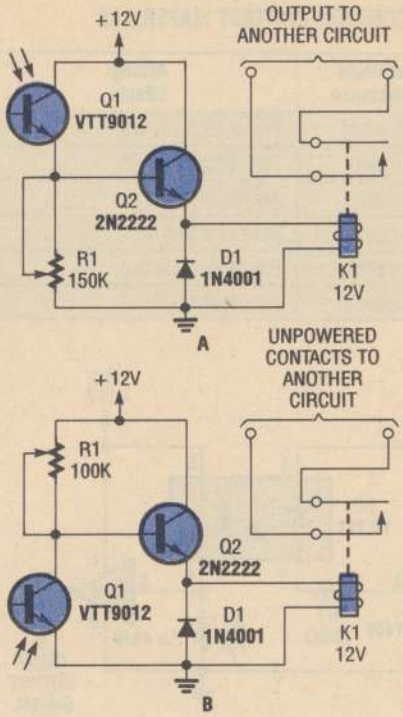


Fig. 7. Phototransistors can be used as either light-activated sensors (A) or dark-activated sensors, depending on how they are interfaced to a circuit.

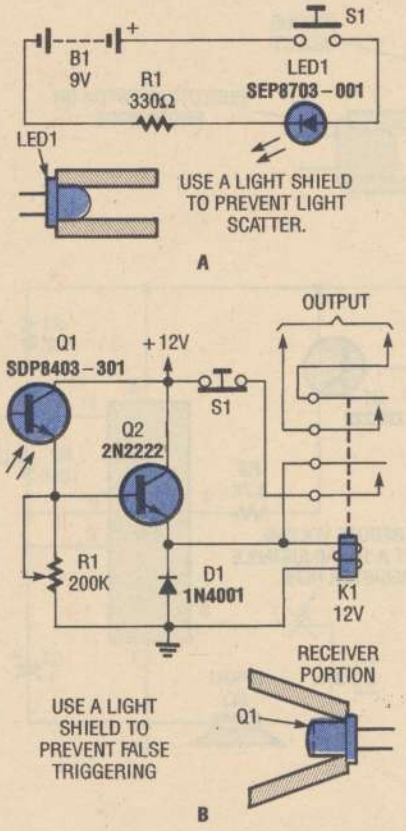


Fig. 8. Shown here is a compete IR remote-control system consisting of a simple transmitter (A) and an equally simple receiver (B).

LED's. An IR LED made with Gallium Arsenide (GaAs) will emit a wavelength of 940 nanometers. An IR LED fabricated from Gallium Aluminum Arsenide (GaAlAs) will produce a wavelength of 880 nanometers.

Figure 8 contains a simple infrared remote-control circuit using the SEP8703-001 IR emitter in the transmitter (Fig. 8A), and a SDP8403-301 IR phototransistor in the receiver (Fig. 8B).

The transmitter portion of the system is very straightforward. A 9-volt battery provides power for the remote transmitter. When S1 is pressed, the IR LED is forward biased and will emit a continuous optical output. Current through the LED is limited by resistor R1. The receiver is a modification of the light-activated sensor shown in Fig. 7A. The IR from the transmitter turns on the phototransistor (Q1) whose sensitivity is adjusted by the variable resistor R1. When Q1 is activated, the driver transistor (Q2) will fire and activate the SPDT 12-volt relay.

Notice that one set of the normally open relay contacts will short Q2 when the circuit is activated. That latches the relay on. In order to disengage the circuit after it has been tripped, you would momentarily press the normally closed pushbutton S1. That breaks the flow of current to the relay so it releases.

Optoisolator Pairs. A great advantage to using optical transmitters and receivers is that there is no actual physical connection between the sending circuit and the circuit that is receiving. Both circuits are then said to be "electrically isolated" from one another. Such isolation is very useful when an interface is required between two completely incompatible types of circuits. For example, a TTL logic gate cannot deliver enough current to drive a relay directly. Some form of isolation is needed to deliver the appropriate voltage and current to a relay under the control of a TTL gate. An optical emitter and detector, or an "optoisolator pair" can be used for that purpose.

The "enclosed pair" configuration like that shown in Fig. 9A is used almost exclusively for electrical isolation. As shown, the emitter and detector are usually placed very close together in a light-tight rigid-plastic enclosure. The pairs may consist of a neon bulb

TABLE 1—CHARACTERISTICS OF COMMON CONTACT MATERIALS

Metal	Resistivity (micro-ohms/cm)	Oxidation Resistance	Arcing Effects
Gold	2.42	Excellent	Pits at high current
Molybdenum	5.70	Good	Pits at high current
Palladium	11.00	Fair	Resists arcing
Platinum	10.60	Very good	Resists arcing
Silver	1.63	Excellent	Pits at high current
Tungsten	5.52	Good	Resists arcing

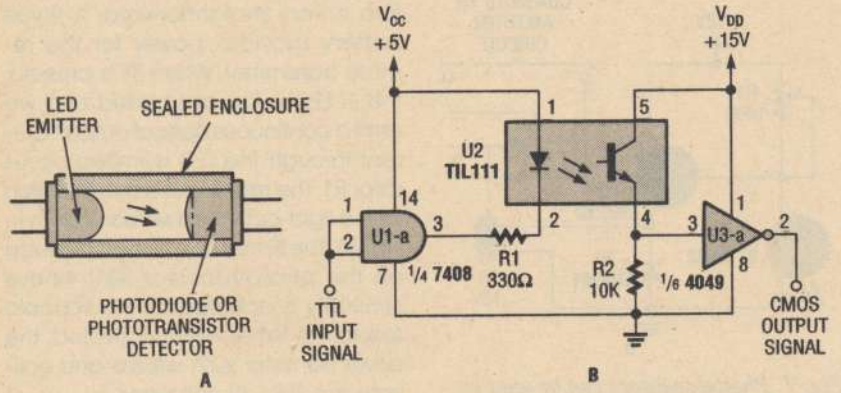


Fig. 9. Enclosed-pair isolators like the one in A are generally used in industrial control systems. Hobbyists are more likely to come across optoisolators in IC packages, as shown in B.

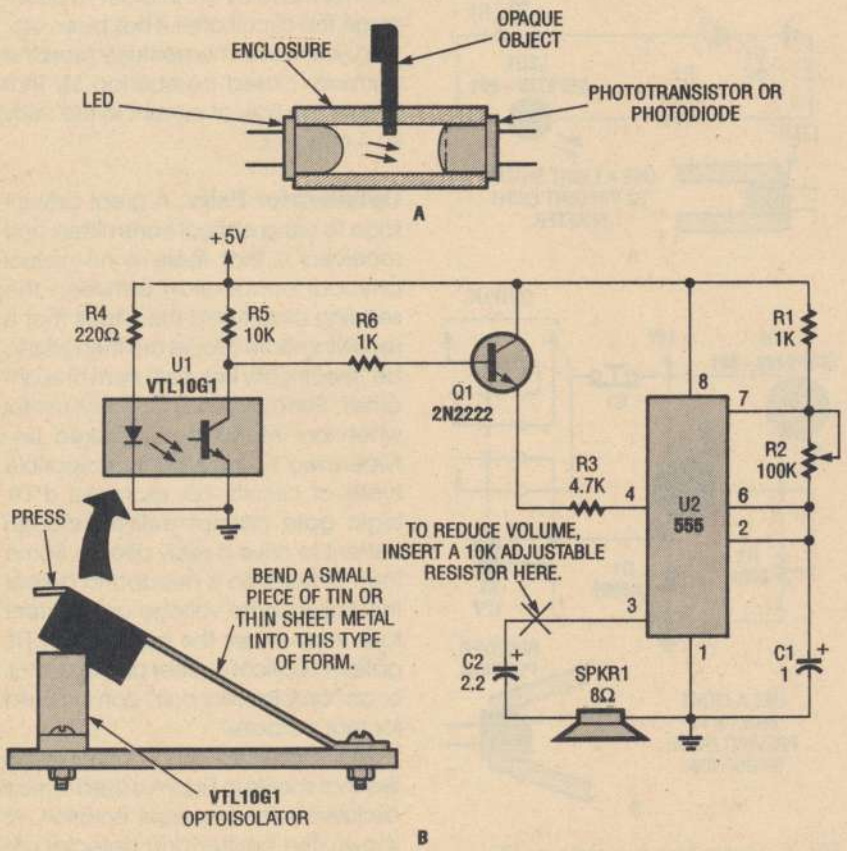


Fig. 10. A slotted-pair isolator (A) is effectively an enclosed-pair isolator with a slit that will allow an obstacle to interrupt the light path. That could be useful for building a code key (B).

and a photocell, an incandescent lamp and a photocell, an infrared transmitter and a phototransistor or photodiode, etc.

The type of package shown in Fig. 9A is called a Vactrol. Optoisolators of that type are typically used for high-power applications. There are a large number of low- to medium-power optoisolators available in IC packages as well.

The circuit in Fig. 9B is a simple voltage-conversion interface that can be used to translate TTL logic levels into CMOS logic levels. A TTL signal is buffered through the 7408 AND gate which drives the LED input of the TIL-111 optoisolator. A logic 1 TTL signal in will turn off the LED and thus the phototransistor. This removes the presence of V_{dd} from the inverter's input allowing R2 to pull it low. The 4049 output will therefore become a CMOS logic 1, thus duplicating the original TTL logic signal at CMOS voltage levels.

Note how the TTL logic and CMOS logic are totally isolated from one another, yet the flow of logic is carried through. This technique of optoisolation is widely used in electronic circuits for its simplicity and its flexibility.

The Slotted Pair. A second very popular sensor pair is the "slotted pair" shown in Fig. 10A. Applications for slotted-pair sensors can range from limit switches, position sensors, and optically debounced switching, to many forms of object-motion and location sensing.

The circuit in Fig. 10B uses a model VTL10G1 slotted photoswitch as a bounceless optical switch for a Morse-code keyer. The source IR LED is kept on at all times. Its current is limited by resistor R4. When the key is up in its resting position (see the key construction detail of Fig. 10B), the LED will keep the phototransistor on. That shuts off the 2N2222A transistor and disables the tone output from the 555 timer.

When the code key is pressed, it breaks the light path between the emitter and the detector. The phototransistor will shut off triggering Q1. Current will flow through Q1, and the 555 will generate a tone through the speaker. The tone will sound as long as the key is depressed. The tone frequency may be adjusted via the 100k variable resistor (R2), or capacitor C1.

A 10k volume-control potentiometer may be inserted into the circuit where indicated if the circuit's volume is too high.

Note that there are three leads at the phototransistor side of the VTL10G1. The center lead is a base lead for the phototransistor. In some circuits, it may be useful to trigger the receiver electronically to override the optical input. However, if you wish to build a circuit like the one shown, leave it disconnected.

The Reflector Isolator. The third general type of optical sensor configuration is the "reflector isolator" that is shown in Fig. 11A. As the name implies, this type of sensing arrangement relies on the optical energy that is reflected from an object to trigger the detector. Since the optical energy reflected decreases as the object moves away, it is possible to use this arrangement to measure the proximity of an object, as well as its location. For reliable performance, one must keep the range of the pair limited by keeping the angle of the detector at 45 degrees to the LED, or greater. That will force the detector to sense reflections at a point that is closer to the infrared emitter, where emitter power will be greater.

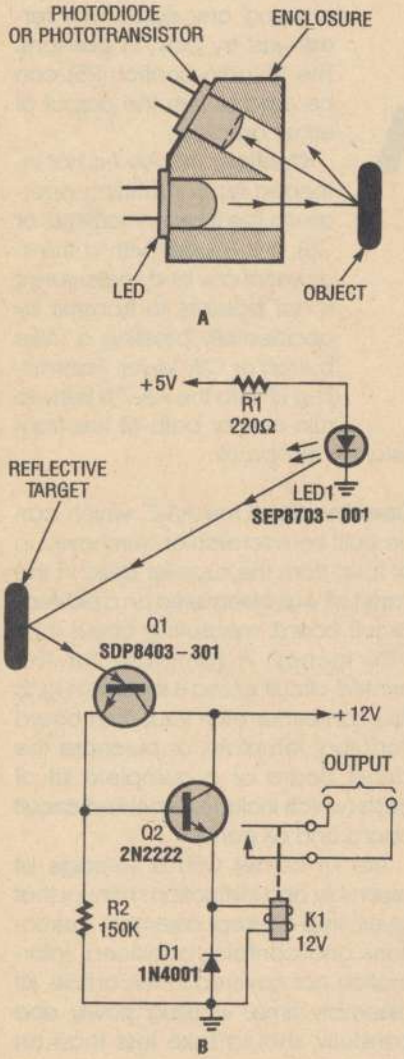


Fig. 11. A "reflector" isolator (A) detects the presence of an object by bouncing light off of it. This is useful in circuits that detect when an object is close enough to the sensor (B).

A simple optical proximity sensor is shown in Figure 11A. The IR LED is driven continuously, and the phototransistor (Q1) will receive any reflected IR energy to trip a light-activated sensor. With nothing to reflect against, Q1 and Q2 will remain off.

The closer an object moves to the IR LED the more energy it will reflect towards the phototransistor. When Q1 is sufficiently stimulated by the IR light it will begin to conduct current. Then Q2 will fire and turn on the 12-volt relay. The relay will continue to stay on as long as the object remains within range. The circuit turn-on point can be adjusted by setting R2.

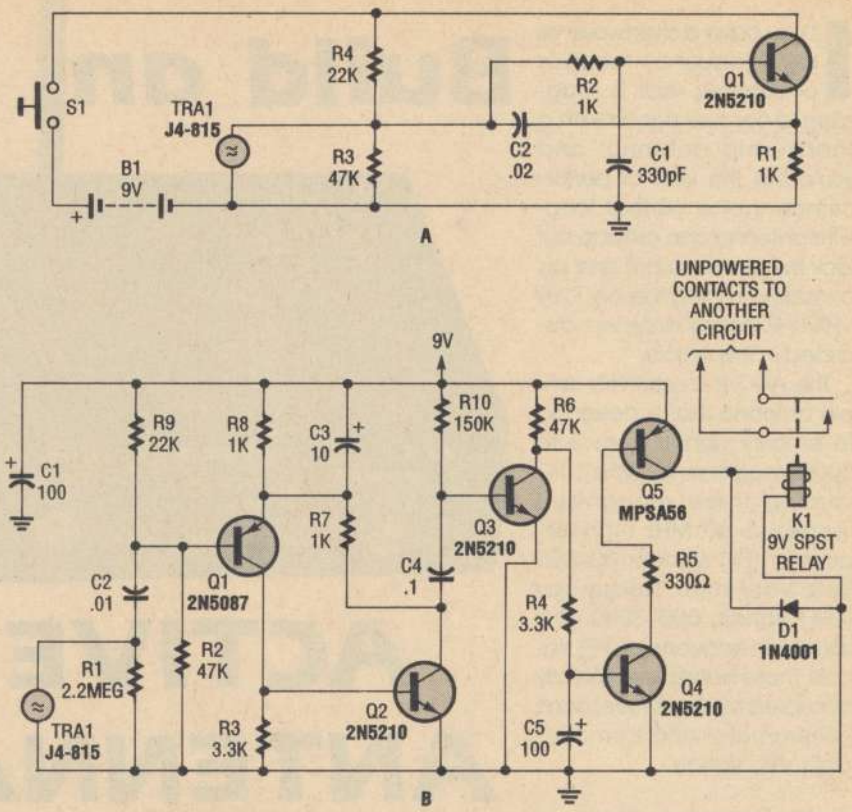


Fig. 12. One type of ultrasonic transducer, namely the J4-815, can be used both in the transmitter (A) and the receiver (B) of a simple ultrasonic remote-control circuit.

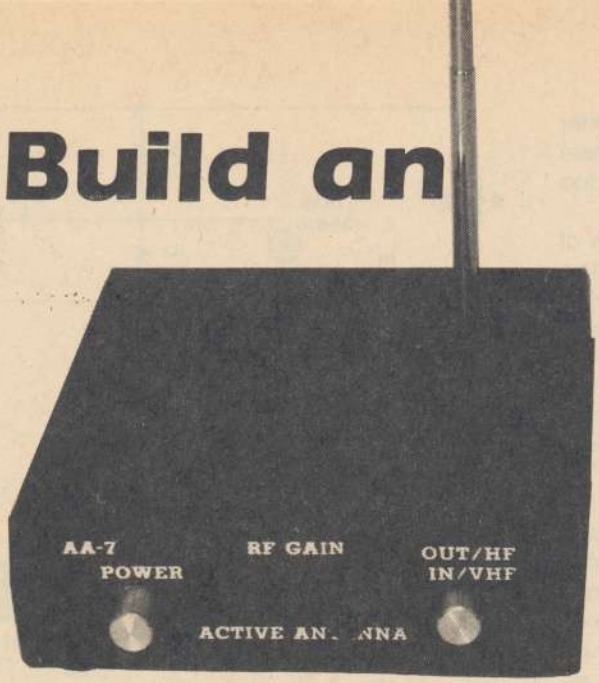
Ultrasonic Transducers. An echo is a perfect example of object detection by sound. First a sound is emitted into the air. When those sound waves strike an object, some of that sound energy will be reflected back to the sender. A larger object will reflect more sound to produce a larger echo. The time taken for the sound sample to travel from the transmitter to the object and back again to a detector can be used to determine the distance of the object. The signal produced by the echo can be used to trigger an alarm if an object is too close.

If several sound samples are taken in succession, any differences in travel time will indicate that the object is in motion. This is the basic principle behind older motion detectors used in security systems.

The J4-815 device shown in Fig. 12 is an ultrasonic transducer made by GC Electronics. It may be used as either a transmitter or a receiver, depending on the circuit it is used in. The transducer is designed to send or receive a frequency of 40 kHz, which is well above the range of human hearing.

(Continued on page 85)

Build an



ACTIVE ANTENNA

Lift hard-to-hear signals out of the mud with this handy receiver accessory.

BY FRED BLECHMAN

If you have a shortwave or high-frequency receiver or scanner that is struggling to capture signals with a short, whip antenna, and you'd like the kind of performance that a 60-foot long-wire antenna can provide but lack the space to put one up, consider building the *AA-7 HF/VHF/UHF Active Antenna* discribed in this article.

The AA-7 is a relatively simple antenna that is designed to amplify signals from 3 to 3000 megahertz (MHz), including three recognized ranges: 3–30 MHz high-frequency (HF) signals; 30–300 MHz very-high frequency (VHF) signals; 300–3000 MHz ultra-high frequency (UHF) signals. Those bands are typically occupied by shortwave, ham, government, and commercial radio signals.

Active Antennas. In its simplest form, an active antenna uses a small whip antenna that feeds incoming RF to a preamplifier, whose output is then connected to the antenna input of a receiver. Unless specifically designed otherwise, all active antennas are intended for receive-only operation, and thus should not be use with transceivers; transmitting into an active antenna will probably destroy its active components.

A well-designed broadband active antenna considers field strength of the desired signal (measured in microvolts per meter of antenna length), atmospheric and other noise, diameter of the antenna, radiation resistance, and antenna reactance at various frequencies, plus the efficiency and noise figure of the amplifier circuit itself.

Circuit Description. Figure 1 shows a schematic diagram of the AA-7, which contains only two active elements; Q1 (an MFE201 N-channel dual-gate MOSFET) and Q2 (a 2SC2570 NPN VHF silicon transistor). Those transistors provide the basis of two independent, switchable RF preamplifiers. Two double-pole double-throw (DPDT) switches play a major role in the operation of the AA-7. Switch S1 is used to select one of the two preamplifier circuits (either HF or VHF/UHF). Switch S2 is used to turn off the power to the circuit, while coupling the incoming RF directly to the input of the receiver. That gives the receiver non-amplified access to the auxiliary antenna jack, at J1, as well as the on-board telescoping whip antenna.

With switch S2 in its power-on position, the input and output jacks are disconnected and B1 (a 9-volt transistor-radio battery) is connected to the circuit. With switch S1 in the position shown in the schematic , incoming RF is directed to the HF preamp circuit built around Q1 (an MFE201 N-channel dual-gate MOSFET). The HF preamp operates with an exceptionally low noise level, and is ideal for copying weak CW and single-sideband signals.

When S1 is switched to the other position, the captured signal is coupled to the VHF/UHF preamp built around Q2 (a 2SC2570 NPN VHF silicon transistor), which has excellent VHF through microwave characteristics. With the on-board whip antenna adjustable to resonance through much of the VHF-UHF region (length in feet = 234 divided by the frequency in MHz), the VHF/UHF mode is ideal for indoor and portable use with VHF scanners and other receivers.

Either mode can be used when tuning 3–30-MHz HF signals. The VHF/UHF preamp offers higher gain that the HF preamp, but also has a higher noise level. You can easily choose either amplifier for copying any signal of interest—just try both S1 positions. The RF gain control (R5) can be used to trim the output of either amplifier.

Caution: The AA-7 is not intended for transmitting operations (be it ham, maritime, or CB); If it is used with a transceiver of any kind, make sure it is not possible to transmit by accidentally pressing a mike button or CW keyer. Transmitting RF into the AA-7 is likely to ruin one or both of the transistors in the circuit.

Construction. The AA-7, which can be built from scratch or purchased in kit form from the supplier listed in the Parts List, was assembled on a printed-circuit board, measuring about 4 by 4 11/16 inches. A template for the printed-circuit board is shown in Fig. 2. You can either etch your own board from that template, or purchase the circuit board or a complete kit of parts (which includes a printed-circuit board and all parts).

The kit comes with a 16-page kit assembly and instruction manual that gives step-by-step assembly instructions and contains additional information not covered in this article. Kit assembly time, working slowly and carefully, should take less than an hour.

Most of the parts specified in the Parts List are standard components and can be procured through conventional hobby electronics suppliers.

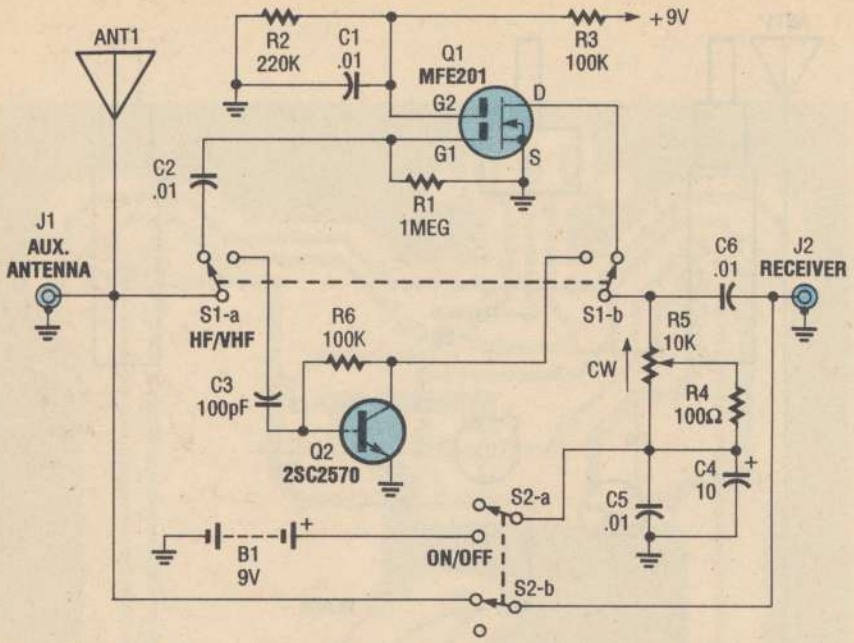


Fig. 1. The AA-7 Active Antenna contains only two active elements; Q1 (an MFE201 N-channel dual-gate FET) and Q2 (a 2SC2570 NPN VHF silicon transistor), which provide the basis of two independent, switchable RF preamplifiers.

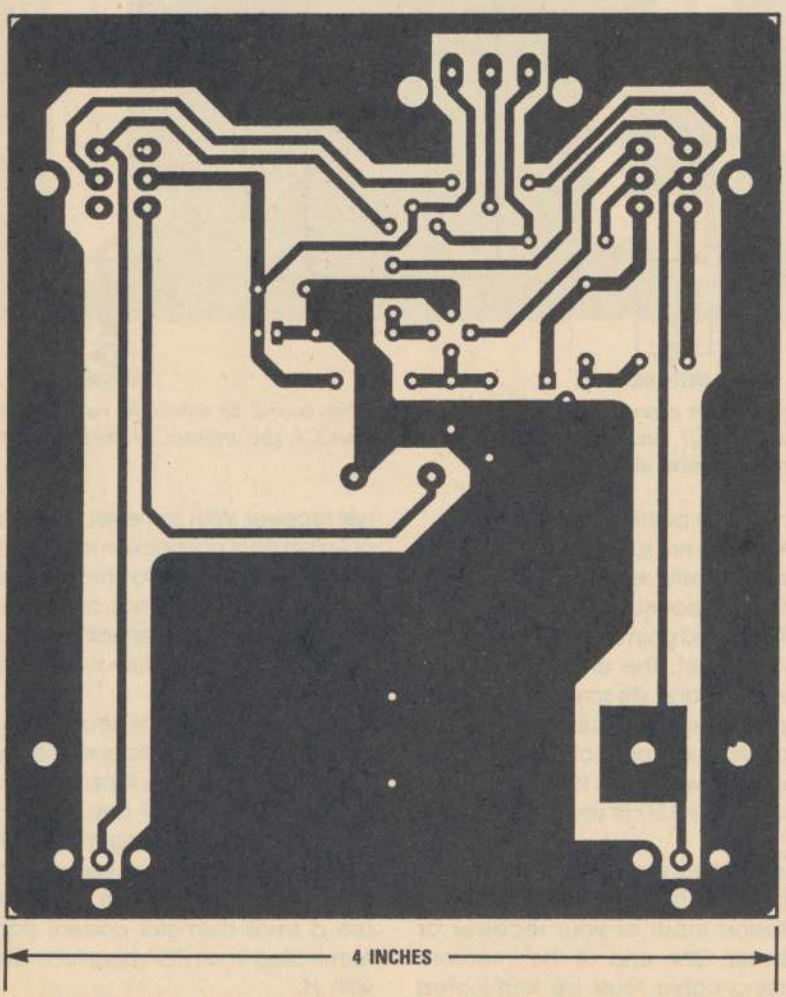


Fig. 2. The AA-7 was assembled on a printed-circuit board, measuring about 4 by 4 11/16 inches. A template for the printed-circuit board is shown here.

PARTS LIST FOR THE AA-7 ACTIVE ANTENNA

SEMICONDUCTORS

Q1—MFE201, 3N204, or SK3991 N-channel, dual-gate MOSFET (see text)*

Q2—2SC2570, 2N5179, or SK9139 NPN VHF silicon transistor (see text)*

RESISTORS

(All fixed resistors are ¼-watt, 5% carbon units.)

R1—1-megohm

R2—220,000-ohm

R3, R6—100,000-ohm

R4—100-ohm

R5—10,000-ohm potentiometer*

CAPACITORS

C1, C2, C5, C6—0.01-μF, ceramic-disc

C3—100-pF ceramic-disc

C4—4.7- to 10-μF, 16-WVDC, radial-lead electrolytic

ADDITIONAL PARTS AND MATERIALS

B1—9-volt transistor-radio battery

S1, S2—DPDT PC-mount pushbutton switch*

J1, J2—PC-mount RCA jack*

ANT1—Telescoping whip antenna (screw mount)*

Printed-circuit materials, enclosure, battery holder and connector, wire, solder, hardware, etc.

Note: The following items are available from Ramsey Electronics, Inc. (793 Canning Parkway, Victor, NY 14564; Tel. 716-924-4560): A complete kit of parts (order #AA-7BP), including printed-circuit board, $24.95; etched and drilled printed-circuit board only (order #AA-7PCBP), $10.00; special parts kit, containing all items marked with an asterisk (*) in the Parts List (order #AA-7SPKBP), $14.50; custom case and knob set (order #CAA-BP), $12.95. Please add $3 for orders under $20, and $3.75 for postage/handling. New York residents, please add appropriate sales tax.

However, some parts—J1, J2, S1, S2, and R5—have particular physical mounting dimensions; the board is designed to accept those parts. In addition, Q1 and Q2 can be hard to find; however, it is possible to make substitutions provided that you can find a supplier. Suitible replacements

for Q1 and Q2 are given in the Parts List.

The telescoping whip antenna screw-mounts to the board; the screw provides contact between the printed-circuit board traces and the antenna. To save time and trouble locating and ordering hard-to-find parts, a Special Parts Kit is also offered by the supplier listed in the Parts List.

A parts-placement diagram for the AA-7's printed-circuit board is shown in Fig. 3. When assembling the circuit, be especially careful that transistors Q1 and Q2, and electrolytic capacitor C4, are oriented as shown.

Although not shown in the schematic (Fig. 1) or the parts-placement (Fig. 3) diagrams, an optional LED power indicator can be added to the circuit. Adding a power indicator to the circuit allows you to tell at a glance if the circuit is on; leaving the circuit on, even though the AA-7 draws only about 0.7 mA, will eventually discharge the battery. Of course, adding an LED will increase the current drain by about 7 mA, but the red glow makes it obvious when the unit is on.

If you decide to include the indicator in your project, power for the indicator can be easily taken from the switched 9-volt DC terminal of S2 (center terminal, right side, looking at the top of S2). Simply connect the positive voltage to the anode (longer wire) of the LED and connect the cathode lead through a current-limiting resistor of about 1000 ohms to a ground point on the printed-circuit board, or as the author did from the frame of R5. Mount the LED at any convenient point near the switch.

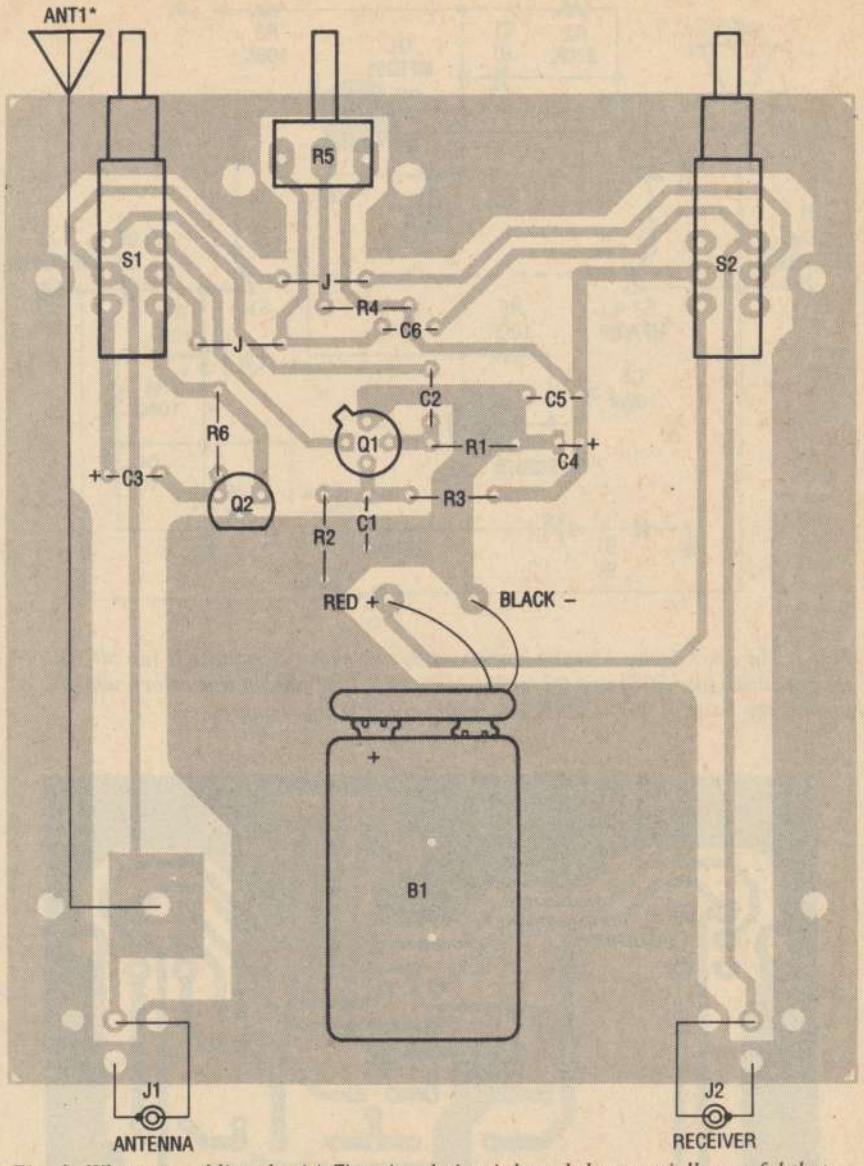


Fig. 3. When assembling the AA-7's printed-circuit board, be especially careful that transistors Q1, and Q2, and electrolytic capacitor C4, are oriented as shown in this parts-placement diagram.

Although not supplied with the kit, a custom plastic enclosure (with front and back panels, and knobs for the switches and gain control) is offered in the Parts List. The enclosure comes pre-drilled and silk-screened with the appropriate legends for all the circuit controls and connectors, but is not equipped with holes for the whip antenna or the LED (if you include one).

Use. Prepare a coaxial cable to connect the RF output of the AA-7 to the antenna input of your receiver or scanner. One end of the interconnecting cable must be terminated with an RCA phono plug; the other end connector depends on the target receiver. With some receivers, the only practical connection is to clip the output of the AA-7 to the receiver's antenna, although that connection method won't be as effective as conventional (ground-return type) coupling.

To increase signal strength, especially for the lower frequencies, you can connect a simple supplementary portable antenna of any design (a dipole, a random-length wire with Earth ground, a bigger vertical whip of some kind, etc.) to the circuit. Just use a small-diameter coaxial cable terminated in an RCA plug for mating with J1.

No alignment is required. If you're

(Continued on page 93)

TYPES OF ACTIVE ANTENNAS

The RF preamplifier section of an active antenna may be of several different styles. A fixed-tuned preamplifier has the greatest gain for the specific frequency of operation, but is limited to only that frequency. A variable-tuned amplifier can be peaked within a range of frequencies, but the circuitry is more complex and expensive, and tuning requires constant resetting whenever the receiver frequency is changed. A broadband preamplifier doesn't require any tuning, making it very versatile and easy to use, but has less gain at any specific frequency. The AA-7 described here, for simplicity and low cost, is of a dual broadband design.

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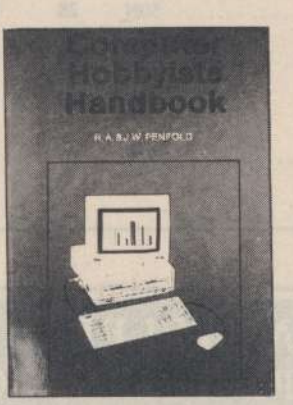

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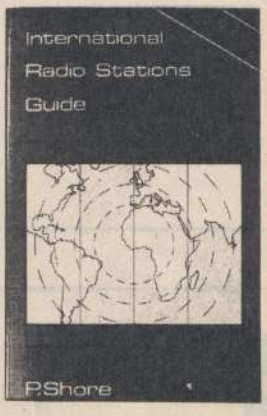

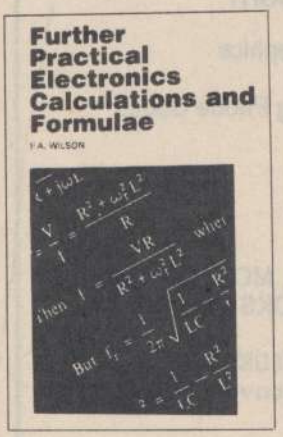

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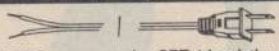

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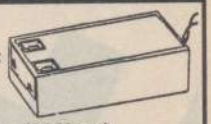

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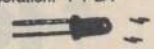

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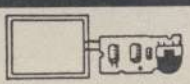

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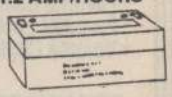

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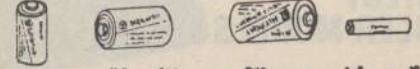

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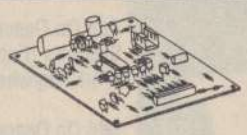

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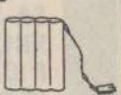

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25	C&S Sales	50D
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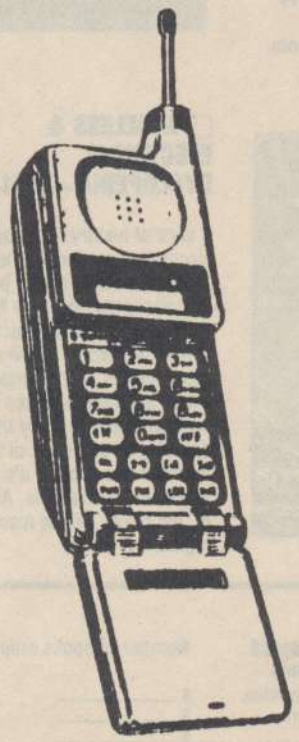

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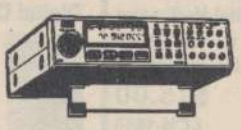

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Compact, digital programmable unit covers 29-54, 136-174, and 406-512MHz. Features scan, WX search, delay, priority, memory backup, lockout, review,& auto delay. Includes AC/DC cords, mtng brkt, antenna. Size: 7 3/8 x 2 1/2 x 1 5/8. Wt: 2.5lbs. Fax fact document #560.

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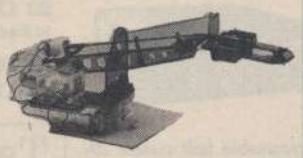

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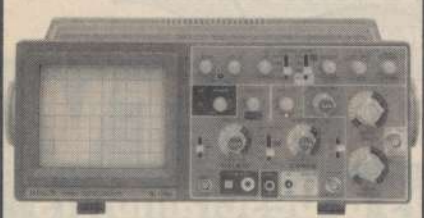

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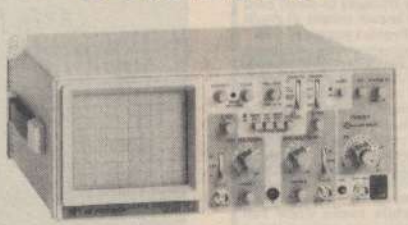

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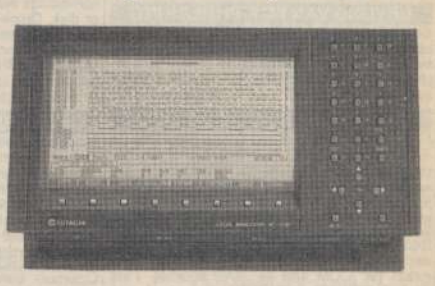

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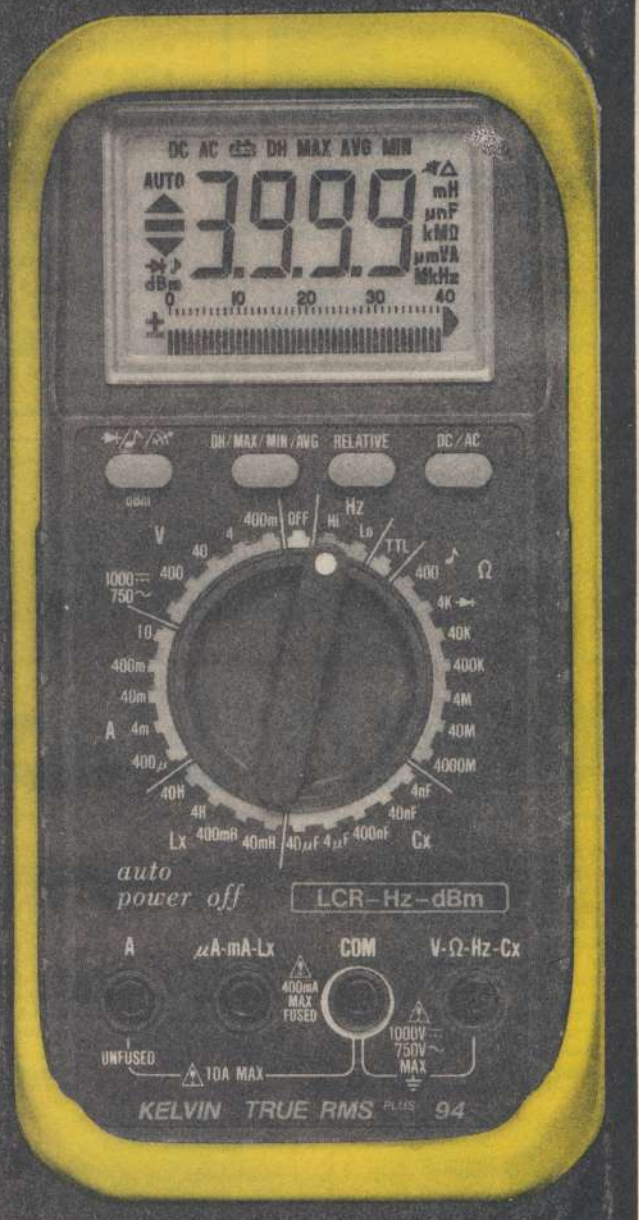

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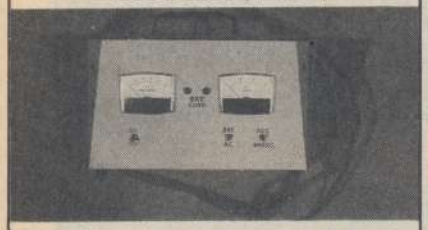

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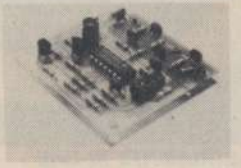

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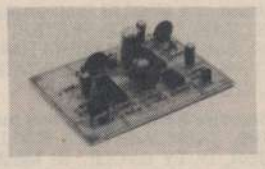

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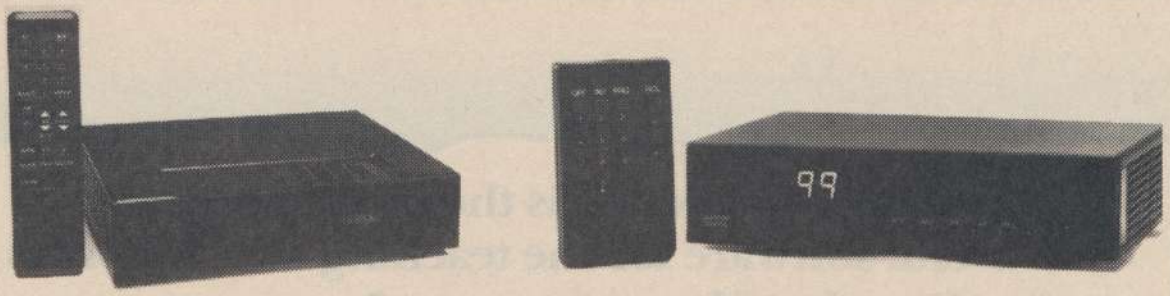

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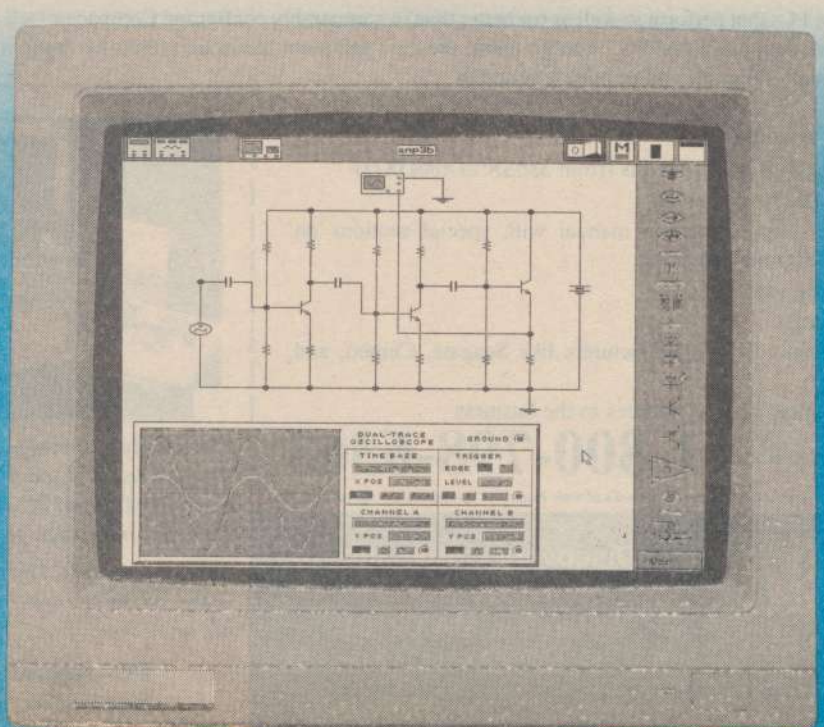

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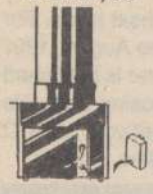

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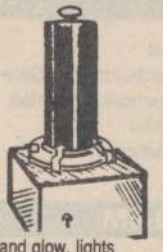

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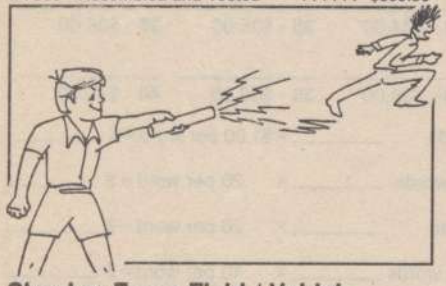

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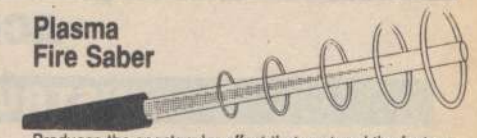


Produces the spectacular effect that captured the fantasy of millions of movie fans. Visible plasma field is controlled by grip pressure and adjusts saber length. Active energy field produces weird & bizarre effects. Excellent for special effects. Specify photon blue, neon red, phasor green, or starfire purple.
PFS2 Plans .... $8.00 PFS2K Kit/Plans $49.50
$pecial Offer PFS20 Assembled reg $89.50, **$59.50**

TV & FM Joker / Jammer

- Shirt pocket device allows you to totally control and remotely disrupt TV or radio reception. Great gag to play on family or friends. Discretion required.
EJK1KM Easy to Assemble Electronic Kit . $19.50

Visible Beam Laser

High brightness red HeNe laser visible for miles. **Produce your own light show!** Projects a beam of red lite clearly visible in most circumstances. Can be used to intimidate by projection of a red dot on target subject. Also may be used to "listen in" using our laser *window bounce* method #LLIS1 below. **Easy to Build Modules Makes A Working Visible Laser:**
LAS1KM Kit w/1mw Laser Tube, Class II . $69.50
LAS3KM Kit w/2.5mw Laser Tube, Class IIIA $99.50

"Laser Bounce" Listener System

allows you to hear sounds from an area via a lite beam reflected from a window or other similar object. System uses our ready-to-use LATR1 Laser Terminator gun site as the transmitter. The receiver section is supplied as an easy-to-build kit, including our cushioned HS10 headsets. **Order # LLIST20 System, includes our LATR1 Ready-to-Use Laser Gun Site, LLR1K Special Receiver Kit, and HS10 Headset, all for only $299.50**

5mw Visible Red Pocket Laser

Utilizes our touch power control!
VRL3KMX Kit / Plans $119.50

See In The Dark Viewing

Device uses invisible infrared illumination for seeing in total darkness. Excellent for low cost night vision,along with observing lasers and other IR sources. Functional unit, many useful applications.

SD5 Plans $10.00
SD5K Kit / Tube / Plans $299.50
GPV10 Ready to Use Viewer $499.50
6032A Tube / Plans to build your own ... $99.50

INFORMATION UNLIMITED

Dept PEM12, Box 716, Amherst, NH 03031
Phone: 603-673-4730 FAX 603-672-5406
MC, VISA, COD, Checks Accepted. Please Add $5.00 Shipping & Handling

Catalog with many more items *FREE* with Order. Or Send $1 P&H

Order by Mail, or by 24 Hour Orders-Only Phone: 800-221-1705

USE PE MARKET CENTER CLASSIFIEDS

READ BY 87,877 BUYERS OF ELECTRONIC EQUIPMENT ACCESSORIES AND PARTS

INSTRUCTION FOR PLACING YOUR AD!

HOW TO WRITE YOUR AD

TYPE or PRINT your classified ad copy CLEARLY (not in all capitals) using the form below. If you wish to place more than one ad, use a separate sheet for the additional ads (a photocopy of this form works well). Choose a category from the list below and write that category number into the space at the top of the order form. If you do not specify a category, we will place your ad under Miscellaneous or whatever section we deem most appropriate.

We cannot bill for classified ads. Payment in full must accompany your order. We do permit repeat ad or multiple ads in the same issue, but in all cases, full payment must accompany your order.

WHAT WE DO

The first two words of each ad are set in bold caps at no extra charge. No special positioning, centering, dots, extra space, etc. can be accommodated.

RATES

Our classified ad rate is $1.00per word. Minimum charge is $15.00 per ad per insertion (15 words). Any words that you want set in bold or caps are 20¢ each extra. Bold caps are 40¢ each extra. Indicate bold words by underlining. Words normally written in all caps and accepted abbreviations are not charged as all-caps words. State abbreviations must be Post Office 2-letter abbreviations. A phone number is one word.

CONTENT

All classified advertising in the **PE Market Center** is limited to electronics items only. All ads are subject to the publisher's approval. We reserve the right to reject or edit all ads.

DEADLINES

Ads received by our closing date will run in the next issue. For example, ads received by April 14 will appear in the August, 1991 issue that is on sale June 18. The PE Market Center is published monthly. No cancellations permitted after the closing date. No copy changes can be made after we have typeset your ad. NO REFUNDS, advertising credit only. No phone orders.

AD RATES: $1.00 per word, Minimum $15.00.

Send your ads with payment to:
Popular Electronics Market Center, 500-B Bi-County Blvd. Farmingdale, NY 11735

CATEGORIES

100 — Antique Electronics
130 — Audio-Video-Lasers
160 — Business Opportunities
190 — Cable TV
210 — CB-Scanners
240 — Components
270 — Computer Equipment Wanted
300 — Computer Hardware
330 — Computer Software
360 — Education
390 — FAX
420 — Ham Gear For Sale
450 — Ham Gear Wanted
480 — Miscellaneous Electronics For Sale
510 — Miscellaneous Electronics Wanted
540 — Music & Accessories
570 — Plans-Kits-Schematics
600 — Publications
630 — Repairs-Services
660 — Satellite Equipment
690 — Security
710 — Telephone
720 — Test Equipment

CLASSIFIED AD COPY ORDER FORM

Ad No. 1—Place this ad in Category # _____

1 - $15.00	2 - $15.00	3 - $15.00	4 - $15.00
5 - $15.00	6 - $15.00	7 - $15.00	8 - $15.00
9 - $15.00	10 - $15.00	11 - $15.00	12 - $15.00
13 - $15.00	14 - $15.00	15 - $15.00	16 - $16.00
17 - $17.00	18 - $18.00	19 - $19.00	20 - $20.00
21 - $21.00	22 - $22.00	23 - $23.00	24 - $24.00
25 - $25.00	26 - $26.00	27 - $27.00	28 - $28.00
29 - $29.00	30 - $30.00	31 - $31.00	32 - $32.00
33 - $33.00	34 - $34.00	35 - $35.00	36 - $36.00
37 - $37.00	38 - $38.00	39 - $39.00	40 - $40.00

Ad No 1—Total words _____ × $1.00 per word = $ _____

All Caps words _____ × .20 per word = $ _____

Bold words _____ × .20 per word = $ _____

Bold Cap words _____ × .40 per word = $ _____

TOTAL COST OF AD No. 1 $ _____

Total classified ad Payment $ _____ enclosed.

[ ] Check [ ] MasterCharge [ ] Visa ($15.00 minimum credit card order)

Card # _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

Expiration Date _ _ / _ _

Signature _____

Name _____ Phone _____

50R Address _____ City State Zip _____

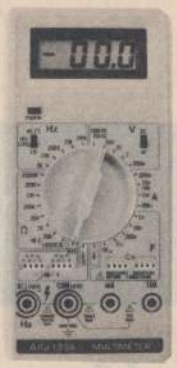
ALFA ELECTRONICS

QUALITY TEST EQUIPMENT
AFFORDABLE PRICE

DMM 2360
$129.95

DMM + LCR Meter
Most Versatile DMM

Inductance: 1µH-40H
Capacitance: 1pF-40µF
Frequency: 1Hz - 4MHz
Temperature: -40 - 302°F
Logic Test: 20MHz
Diode, Continuity
Volt, Amp, Ohm
3999 count display
Peak Hold
Auto power off



DMM 175A $67.95

DMM with 20 MHz Frequency Counter
Most popular DMM

Freq. Counter 1Hz-20MHz
DCV .1mV-1000V
ACV .1mV-750V
ACA/DCA .1mA-10A
R .1Ω-2000MΩ
Cap 1pF-20µF
TTL Logic test 20 MHz
Transistor HFE test
Diode test
LED test
3 ½ digit display
10 MΩ impedance

Fluke Multimeter

Fluke 70 II		$62
Fluke 73 II		$87
Fluke 75 II		$125
Fluke 77 II		$145
Fluke 79 II		$165
Fluke 83		$215
Fluke 85		$255
Fluke 87	True RMS	$285
Fluke 86	Automotive	$359
Fluke 88		$419

LCR Meter 814
$199.95

The Best Handheld LCR

Inductance:0.1µH-200H
Capacitance:0.1pF-20,000µF
Resistance:1mΩ-20MΩ
1% basic accuracy
Dissipation factor indicates leakage in capacitor and Q factor in inductor
Zero adjustment to reduce parasitics from test fixture
Very good for high frequency RF and surface mount components.

LCR Meter 195
$119.95

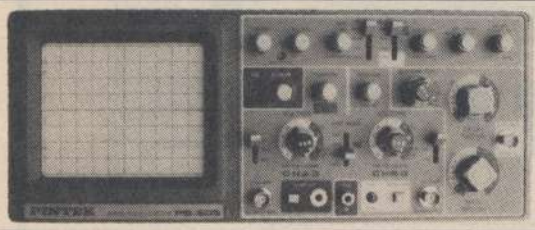
Very popular LCR

Inductance:1µH-200H
Capacitance:0.1pF-200 µF
Resistance:0.01Ω-20MΩ
Basic accuracy:R:1%, C:2%, L:3%
Test frequency 1 kHz

Capacitance Meter 7705 $57.95

0.1 pF-20,000µF in 9 ranges
0.5% basic accuracy
Zero adjustment ± 20pF to compensate parasitics from test fixture

Also Available:
Heavy duty DMM
AC/DC clamp meter
Thermometer, Lux meter
pH meter, Logic probe
High voltage probe
RC oscillator
Electronic scale
Frequency counter



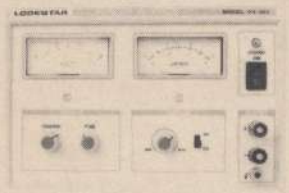
20 MHz Oscilloscope with Delay Sweep PS-205 $429.95

Dual Trace, Component test, 6" CRT, X-Y Operation, TV Sync, Z Modulation, CH2 Output, Graticule Illum, 2 probes x1, x10. Best price with delay sweep.

PS-200 20MHz	DUAL TRACE	$339.95
PS-405 40MHz	DELAY	$569.95
PS-605 60MHz	DELAY	$769.95

20 MHz Digital Storage Oscilloscope DS-203 $769.95

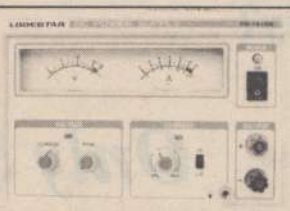
Switchable between digital and analog
2 K word per channel storage
Sampling rate: 10 M sample /sec
8 bit vertical resolution (25 Levels/div)
Expanded Timebase 10ms/div - 0.5 s/div
Refresh, Roll, Save all, Save CH2, Pre-Trig
Plotter Control



Power Supply PS-303 $169.95

0-30 VDC , 0-3A output

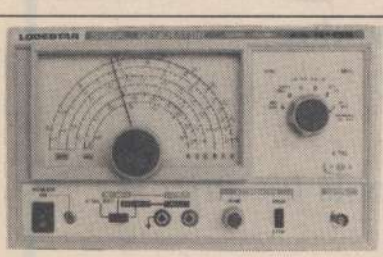
0.02% + 2mV line regulation
0.02% + 3mV load regulation
1 mVrms noise and ripple
Short circuit and overload protected



Power Supply PS-1610 $299.95

0-16 VDC , 0-10A output

Constant voltage & constant current mode
0.2%+2mV line regulation
0.04% +2mV load regulation
1mVrms noise and ripple
Short circuit and overload protected



RF SIGNAL GENERATOR SG-4160B $124.95

100 kHz-150MHz sinewave in 6 ranges
Output 100mVrms to 35 MHz
Internal 1kHz, External 50Hz-20kHz modulation

AUDIO GENERATOR AG-2601A $124.95

10Hz - 1MHz in 5 ranges
Output: 8Vrms sine, 10Vp-p squarewave
Synchronization: ±3% of oscillation frequency per Vrms
Output distortion: 0.05% 500Hz - 50kHz
0.5% 50Hz - 500kHz
Output impedance: 600 ohm

FUNCTION GENERATOR FG-2100A $169.95

0.2 Hz - 2 MHz in 7 ranges
Sine, square, triangle, pulse and ramp
Output: 5mV-20Vp-p
1% distortion, DC offset ± 10V
VCF: 0-10V control frequency to 1000:1

FUNCTION GEN./COUNTER FG-2102AD $234.95

Generates signal same as FG-2100A
Frequency counter 4 digits
Feature TTL and CMOS output

RF SIGNAL GEN./COUNTER SG-4162AD $234.95

Generates RF signal same as SG-4160B
Frequency counter 1Hz -150MHz
Sensitivity <50mV
For internal and external sources

AUDIO GEN./COUNTER AG-2603AD $239.95

Generates audio signal same as AG-2601A
Frequency counter 1Hz-150MHz
Sensitivity <50mV
For internal and external sources

SWEEP FUNCTION GEN./COUNTER 329.95

0.5MHz to 5 MHz
Sweep: Lin 10:1/Log 10:1 20mS to 2S
AM Modulation
Gated Burst, Voltage Control Generator, Generator Control Voltage & 6 digit Counter.

ALFA ELECTRONICS
P.O. BOX 8089 Princeton, NJ 0854

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FAX:(609) 275-9536
Visa, Master Card, American Express, COD, Purchase Order Welcome

15 DAY MONEY BACK GUARANTEE. 1 YEAR WARRANTY
WRITE FOR FREE CATALOG. PRICES SUBJECT TO CHANGE

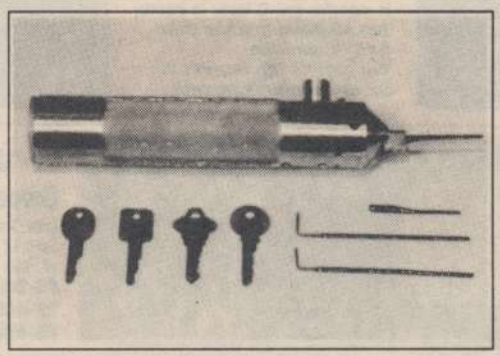
CIRCLE 34 ON FREE INFORMATION CARD

ELECTRONIC LOCK PICK

Need to open any door or padlock?

With the Electronic Pick no locksmithing skill is required!

- **Lock your keys in the car?**
- **No key for a padlock?**
- **Lock yourself out?**
- **Lose a key?**



Only $199.00

Complete with a 128 page manual for opening most locks in less than ten seconds!

Send $5.00 for a complete list of locksmithing tools for any lock, auto lock, luggage, etc.

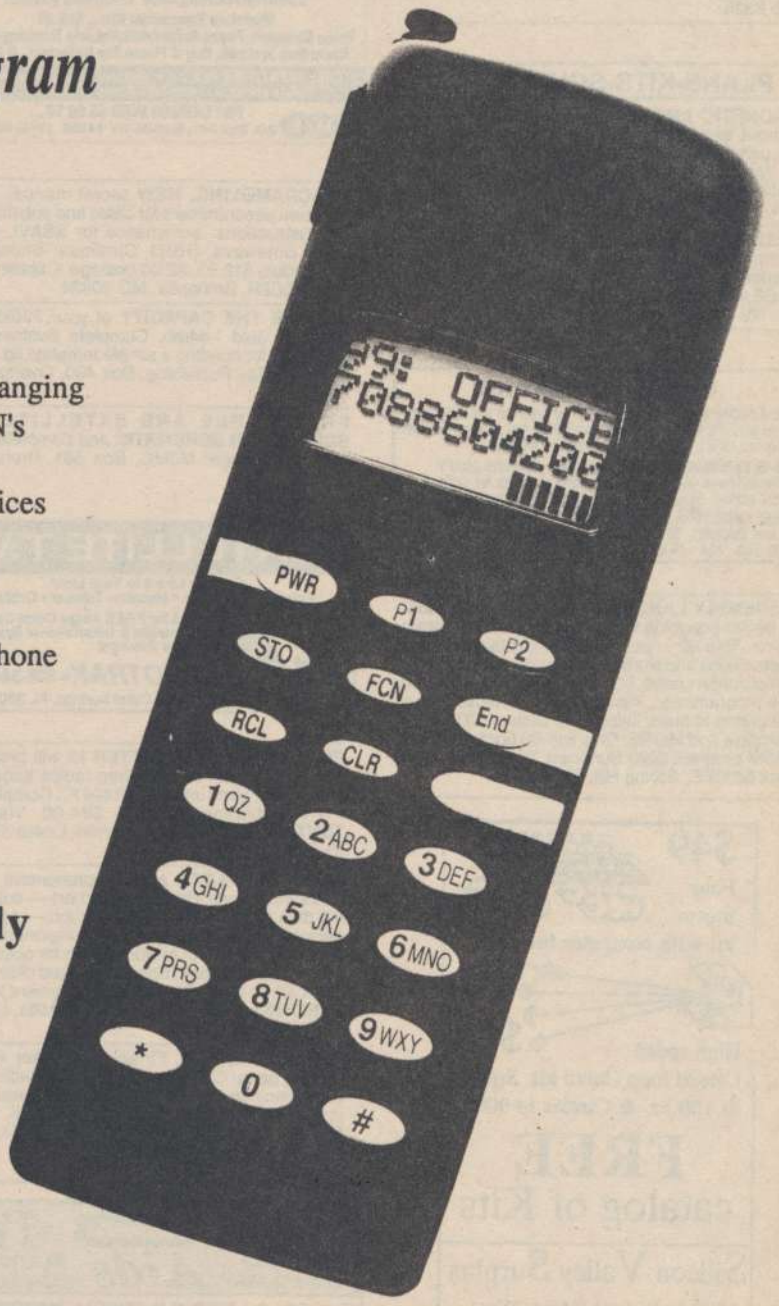
SPY Supply

7 Colby Court Suite 215
Bedford, NH 03110
617) 327-7272

CELLULAR TELEPHONE MODIFICATION HANDBOOK

How do you reprogram a cellular phone?

- Descriptions of cellular phones' vulnerabilities !
- Techniques for decoding and changing cellular phones' NAMS and ESN's
- Where to buy programming devices
- Chip supplier's phone numbers
- Instructions on how to change phone numbers on all models
- Cellular phone manufacturer's ESN codes



Complete Manual only
$79.95

M.O. or C.O.D. to

SPY Supply
7 Colby Court Suite 215
Bedford, NH 03110
(617) 327-7272

Sold for educational purposes only

PE MARKET CENTER CLASSIFIEDS

MISCELLANEOUS ELECTRONICS FOR SALE

GOVERNMENT SURPLUS test equipment and parts. Free catalog. EF Electronics, Box 326, Aurora, IL 60507.

SAMS PHOTO Facts. Complete folders, #1000 to #2291. $8.00 each plus postage. (914) 562-2805.

SOLAR 20W 4V 5A $65.00. 100p CAT $5.00 refundable. Dallas Solar, POB 611927, San Jose, CA 95161. 1 (800) 345-4913.

OSCILLOSCOPE 50 MHz, dual channel, solid state, calibrated, with manual $250.00. 1 (800) 835-8335.

PLANS-KITS-SCHEMATICS

MAGNETIC AMPLIFIER. Solid state amplifier without semiconductors or vacuum. Amplifies through the use of magnetic fields. Plans $10.00, kit (plans + one amplifier) $20.00. **ELECTROMAN,** Dept. PE,.MDBO/.MDNM/ PO Box 24474, New Orleans, LA 70184.

NEED BATTERIES? LEARN HOW TO: salvage rechargeable nicads, keep them fresh until needed for use in radios flashlights etc. Send SASE for details. Day Publishing, Box 490, Overton, NV 89040.

PRINTED CIRCUIT KIT

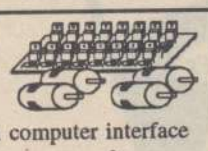
ER-4 PHOTO ETCH™ kit lets you copy art from this magazine onto your PC board. Includes everything but exposure bulbs. Shipped UPS to your street address for $43.00.

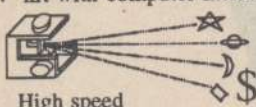
ER-19 EXPOSURE BULB SET FOR ER-4. Contains 3400°K reflector flood and 4800°K long wave UV lamp for ordinary 120V socket. Shipped UPS to your street address for $18.45.

FREE CATALOG of dry transfers and PC supplies. Write or phone **DATAK,** 55 Freeport Blvd, Sparks, NV 89431. 702-359-7474 FAX: 702-359-7494.

ASSEMBLY LANGUAGE BASICS for the 8051. A beginners guide to the world of .ASM programming. This 60+ page booklet contains detailed instructions and working programs. Includes 8051 initialization codes, I/O, serial port and LCD Module programming. Also includes schematics and programs to build; Telephone Dialer, LCD Dialing Displays and MORE. Only $16.00 (includes 360K .ASM program disk) Suncoast Technologies, PO Box 5835PE, Spring Hill, FL 34606.

$49
Four motor kit with computer interface





$99
High speed Closed loop Galvo kit Squares to 180 hz, & Circles to 900 hz

FREE catalog of Kits

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Bldg 460
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BUILD — FIVE-digit, ohms, capacitance, frequency, pulse, multimeter. Board and instructions $9.95. Bagnall Electronics, 179 May, Fairfield, CT 06430.

BUILD YOUR own neighborhood radio station with our high quality FM stereo transmitter kit. Also available ham transceiver kits. Send SASE for complete catalog. **Sunset Electronics,** 16776 Bernardo Center Drive, Suite 110B, San Diego, CA 92128.

SURVEILLANCE

COUNTERSURVEILLANCE Electronic Devices
Miniature Transmitter Kits.. $29.95
Voice Changers, Phone Scramblers, Vehicle Tracking, Phone Recording Systems, Bug & Phone Tap Detectors, & More!
CALL IDENTIFIER device • displays callers phone number before you answer with date & time of call...$49.95
FOR CATALOG SEND $5.00 TO...
EDE P.O. Box 337, Buffalo, NY 14226 (716) 691-3476

DESCRAMBLING, NEW secret manual. Build your own descramblers for cable and subscription TV. Instructions, schematics for SSAVI, gated sync, Sinewave, (HBO, Cinemax, Showtime, UHF, Adult) $12.95, $2.00 postage. Cabletronics, Box 30502R, Bethesda, MD 20824.

DOUBLE THE CAPACITY of your 720kb diskettes to hold 1.44mb. Complete illustrated instructions for building a simple template jig. Send $2.00 to: Day Publishing, Box 490, Overton, NV 89040.

FREE CABLE AND SATELLITE DESCRAMBLER SCHEMATIC and complete information package. MJMC, Box 531, Bronx, NY 10461.

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Factory Direct to Your Door
Echostar • Startrak • Houston Tracker • Orbitron
24 Hr. Pricing Hotline 516-763-6842
• Call for FREE Huge Color Catalog
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• Huge Savings!
Info & Orders
ECHOTRAK™ 305-344-6000
4749 NW 98th Lane • Coral Springs, FL 33076

FM STEREO TRANSMITTER kit will broadcast any audio signal to FM stereo radios throughout your home. Uses unique BA1404 IC. Complete kit: PC board/components — $24.00. Visa/MC. **TENTRONIX,** 3605 Broken Arrow, Coeur d'Alene, ID 83814. (208) 664-2312.

MOST COMPLETE and comprehensive — resistor color code identification chart — coil winding data chart — L,C, F, nomagraph — capacitor decipher chart. Stop mystery of component identification. Post charts at work bench for quick component identification. Specify required chart, each chart $3.00 all for $10.00. Send payment to **TMS ELECTRO-DATA, INC.,** 4096 S.E. Mills, Lawton, OK 73501.

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Test chips for JERROLD, TOCOM, ZENITH, S.A. & more. Puts cable boxes in full service mode. Easy installation. Zenith only $39.95. Most others under $50ea. Quantity prices available.
No Ch. sales. Not for use in cable co. owned equip. For use as a test aid only.

AUDIO-VIDEO-LASERS

LASERS 1MW He-Ne laser module $55.00; 1.5mW $69.00. Requires 12VDC. 120VAC operation add $20.00. 30 day satisfaction guarantee, 6 month warranty. Please add $7.00 S&H. Free catalog — write: **Midwest Laser Products,** PO Box 2187, Bridgeview, IL 60455. Or poll our Fax (708) 430-9280. Phone: (708) 460-9595.

SATELLITE EQUIPMENT

REVOLUTIONARY DIGITAL DIRECT BROADCAST SATELLITE SYSTEM Ground floor marketing opportunities. For information write: P-Systems, 7640 Cherry Tree, Willowbrook, IL 60514.

VIDEOCYPHER II descrambling manual. Schematics, video, and audio. Explains DES, Eprom, CloneMaster, 3Musketeer, Pay-per-view (HBO, Cinemax, Showtime, Adult, etc.) $16.95, $2.00 postage. Schematics for Videocypher Plus, $20.00. Schematics for Videocypher 032, $15.00. Collection of software to copy and alter Eprom codes, $25.00. Cabletronics, Box 30502R, Bethesda, MD 20824.

SATELLITE TV SYSTEMS Factory direct shipments on **ECHOSTAR, STARTRAK, TRACKER** and **ORBITRON. LNB's,** feedhorns, motors, cable and accessories. Domestic and international systems. Call for free color catalog. Huge discounts. **24 HOUR PRICING HOTLINE** (516) 763-6842 **ORDERS AND INFO** (305) 344-6000 **ECHOTRAK.**

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LEARN TO EARN Increase your income with electronic skills. Courses written for easy learning. **As low as $49.50.** Send $2.00 for course and parts catalog to A&A Products, Rt1 Box 482-L, Rockdale, TX 76567.

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PC PARTS, Mbs, disk drives, hard drives etc. Overstocks, reconditioned. Multiwatt Systems, Box 1147, Burlington, MA 01803. Fax: (617) 229-9798.

MC68HC11F1 MICROCONTROLLER: Allows a Master/Slave RS485 network of controllers and PCs. Complete hardware/software package includes: Hardware, 32K ROM 32K RAM, 20 digital and 8*8-bit A/D I/O, RS232, watchdog, timers/counters, single +5V supply; Software, free GNU C cross-compiler (PC/DOS), Network firmware and libraries, ROM monitor/debugger, multi-tasking executive, PC tools to: monitor network, download code across network, use PC as node (no additional hardware), application libraries for motor control and sensor sampling. User manual. Source code available! Price $179.00 + shipping. Coactive Aesthetics, PO Box 425967, San Francisco, CA 94142. (415) 626-5152, fax (415) 626-6320. Internet: coactive@coactive.com.

SUPPORT RESEARCH.
It Works Wonders.
American Heart Association

WHOLESALE SPECIALS

LIMITED QUANTITIES

CABLE CONVERTERS

Blow Out!!

Jerrold 400 Refurbished

60 Channel Remote w/fine tune

6 Month Warranty New Transmitter

400 MHZ 60 Channel **$59.95** each

$55.00 each - 5 lot • $50.00 each - 10 lot

$45.00 each - 20 lot • $40.00 each - 50 lot

$37.50 each - 100 lot

New Zenith SSAVI
Power Supplies Available

MTS Stereo Processors for SSAVI
Available - Works with any Cable Converter

VIEWSTAR IS HERE

MXC-2520-525 MHZ remote volume remote volume control	
Audio/video Baseband	$119.95 ea.
Output, decoder loop	$90.00 5 lot
Parental Lockout	$85.00 10 lot
Favorite channel	$80.00 20 lot
Remote Fine tuning	
'Universal' Descrambler Compatible	

NEW "NORTH COAST"

'Excel' 66 channel remote	$99.95 ea.
Fine tune remote, 60 min. Sleep timer	$80.00 5 lot
Display dimmer Favorite channel	$75.00 10 lot
Parental Lockout, HRC/STD Remote	$70.00 20 lot

Selectable Twinline A/B Select Optional

AMERICAN MADE Keep *OUR* People Working

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24 Hour Service **(708) 697-0600** **Mon - Fri 8:30 - 5 pm - CST**

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Prairie Digital, Inc.

MODEL 70 18 BIT (5.5 DIGIT)
A/D WITH RS232 INTERFACE $239

- ★ Inexpensive: Equivalent resolution of 5 1/2 digit DVMs costing over $1000! FAST - - 16.7 to 133 ms/conversion depending on resolution and mode.
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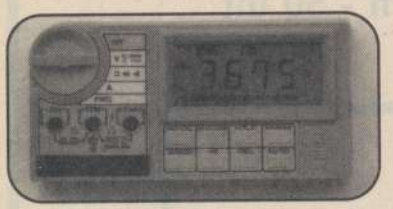

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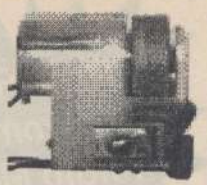

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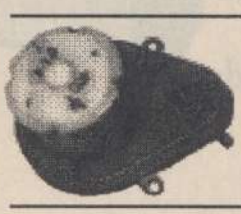

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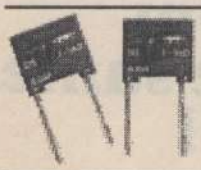

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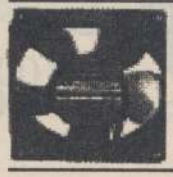

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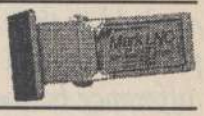

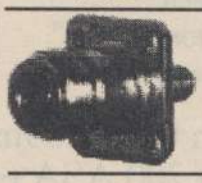

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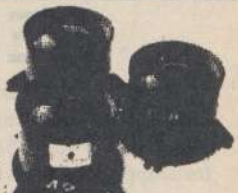

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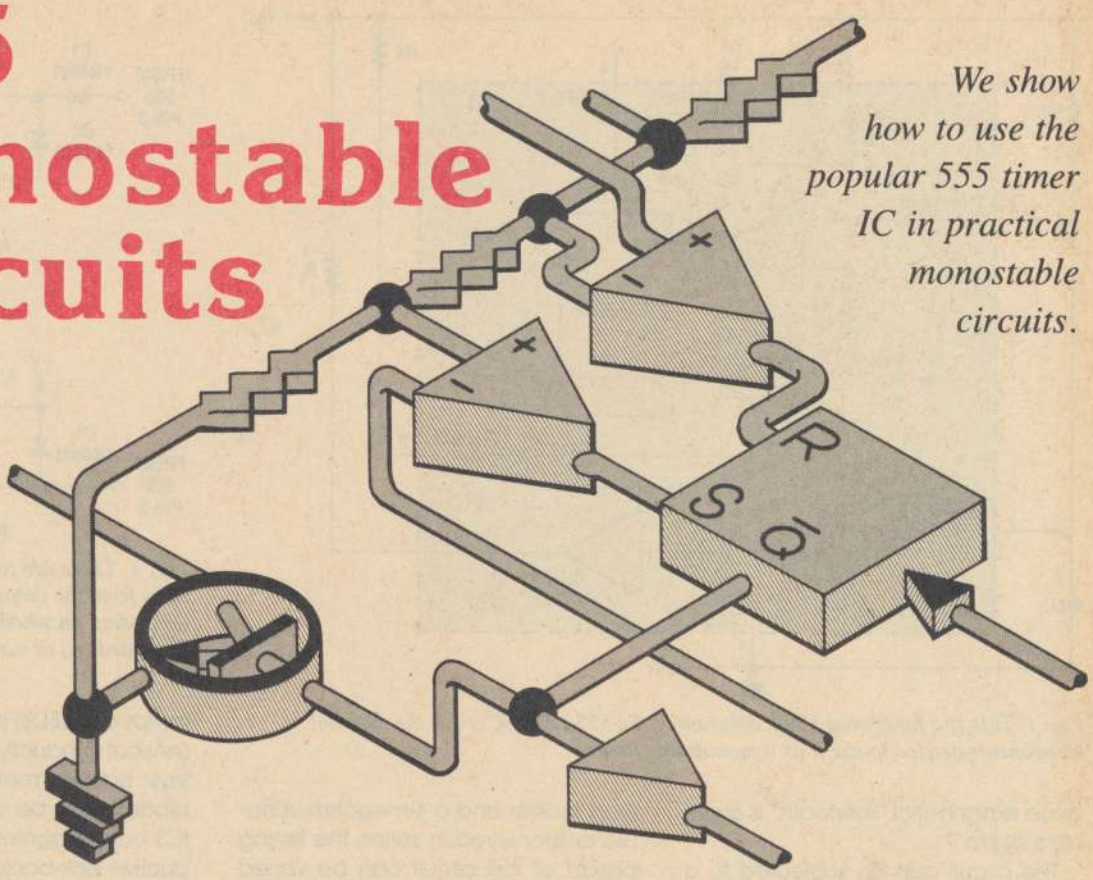
555 Monostable Circuits

We show how to use the popular 555 timer IC in practical monostable circuits.

BY RAY MARSTON



The 555 timer is one of the most useful and popular IC's ever made. It is inexpensive, readily available, and can easily be used to make a variety of "monostable multivibrator circuits." In such applications, the IC's output changes state on the arrival of a suitable pulse, but automatically resets again after a pre-set time delay. In this article, we'll show how to use the 555 to form some useful monostable circuits.

555 Timer Basics. The standard 555 timer IC is a robust and easy-to-use device that is housed an an 8-pin DIP. It can be used with any DC supply in the 4.5- to 16-volt range, consumes a quiescent current of only a few milliamps, and can drive up to 200 mA of current into an external load connected to its output terminal. Figure 1 shows a functional diagram of the IC and the external components and connections needed to make it act as a basic "triggered timer" or monostable multivibrator. Note that the internal resistors, R1 through R3, form a supply-driven voltage divider. That network generates a $\frac{1}{3}V_{CC}$ reference voltage on the non-inverting input of the lower comparator and a $\frac{2}{3}V_{CC}$ reference on the inverting input of the upper comparator. The comparator outputs control the R-S flip-flop, which in turn controls the output stage and slave-transistor Q1. The flip-flop state can also be controlled via pin 4.

When the timer circuit is in its normal quiescent state, pin 2 is held high via R4, the transistor is switched fully on (saturated) to form a short across timing capacitor C_T, and the IC's output (pin 3) is low. The monostable timer action can be initiated by feeding a negative-going trigger pulse to pin 2. When the pulse falls below the internal $\frac{1}{3}V_{CC}$ reference voltage to the lower comparator, that comparator changes state and triggers the flip-flop. That turns Q1 fully off and drives the output at pin 3 high. Since Q1 turns off, it removes the short from across C_T, which then charges exponentially via R_T until its voltage rises to $\frac{2}{3}V_{CC}$. At that point, the upper comparator changes state and switches the flip-flop state again, turning Q1 on to rapidly discharge C_T and also switching pin 3 low again.

Note that once triggered, this circuit cannot respond to another trigger pulse until the timing sequence is complete, but the sequence can be aborted at any time by feeding a negative-going pulse to the reset input at pin 4. The timing period (T) over which pin 3 remains high, is given as:

$$T = 1.1\, R_T\, C_T$$

where T is in seconds, R_T is in ohms, and C_T is in farads.

In practice, R_T can have any value between 1000 ohms and 10 megomhs, and C_T (which should be a low-leakage component) can have any value in the range from 1 nF to 100 µF.

A Practical Timer Circuit. Figure 2A shows a practical fixed-period (about 50 sec) manually-triggered 555 timer, and the waveforms of the important points in the circuit are shown in Fig. 2B. The circuit is similar to the circuit model back in Fig. 1. However, in the Fig. 2 circuit, the timing action is initiated by briefly closing S1, pin 5 is decoupled from noise via C2, and the output state is visible via LED1. As you can see from Fig. 2B, the fixed-period output pulse (set via R1 and C1) is available at pin 3, and a high-imped-

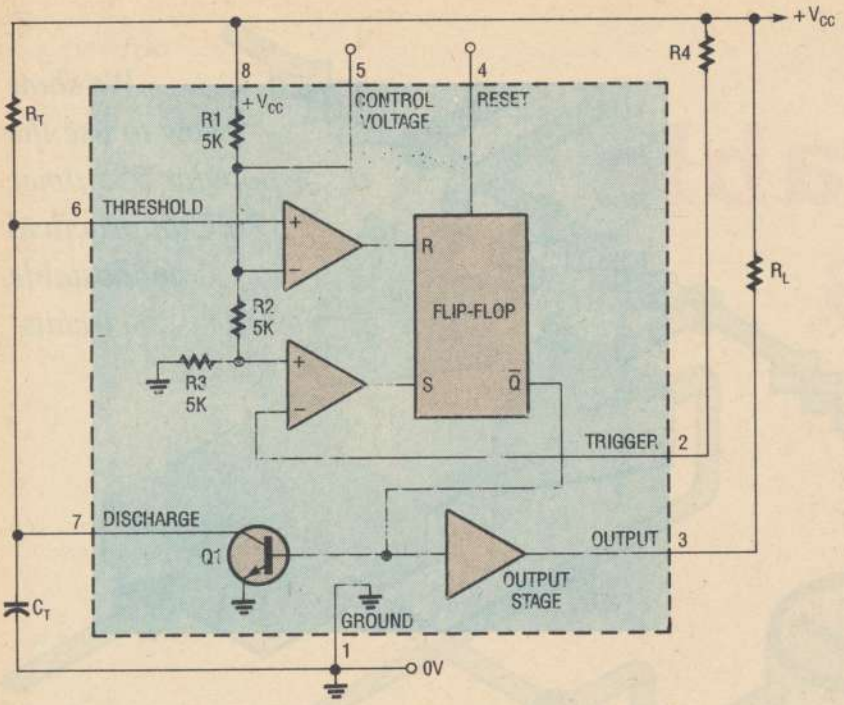


Fig. 1. This is a functional block diagram of the 555 timer IC, with the external components needed to use it as a monostable timer.

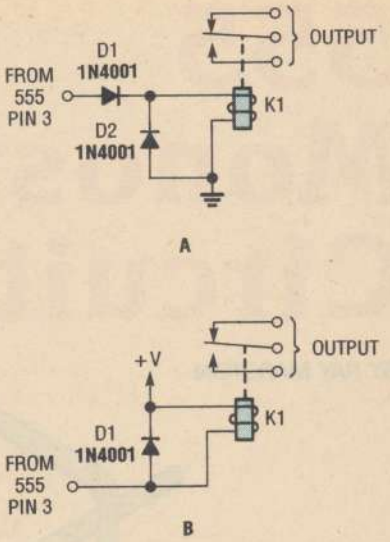


Fig. 3. There are two ways of driving a relay from the output of a 555, depending on whether the relay is grounded (A) or connected to V+ (B).

ance exponential "sawtooth" is available at pin 7.

The circuit can be subjected to a variety of useful modifications. For example, by replacing R1 with a 10k fixed resistor and a 1-megohm variable resistor wired in series, the timing period of the circuit can be varied from 1.1 to 120 seconds. A reset facility can also be added by connecting the reset pin to V+ through a resistor, and momentarily bringing it low through a pushbutton switch, just like the trigger input.

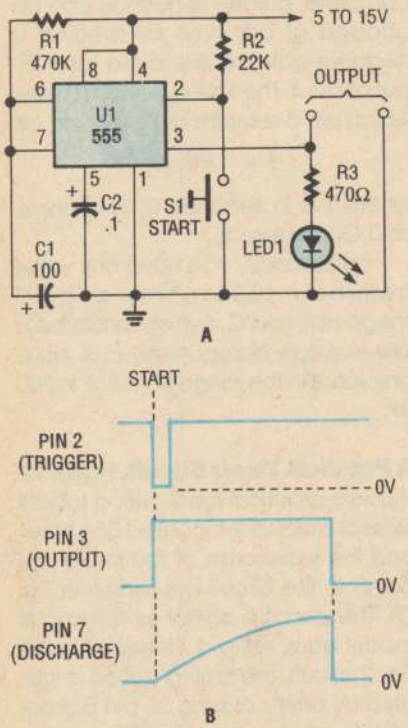


Fig. 2. The circuit for a a simple 50-second timer is shown in A; note its similarity to the previous circuit. The waveforms produced at different points in the circuit are shown in B.

Relay-Output Designs. A 555 timer can be used to directly drive a variety of loads via pin 3. They can directly drive non-inductive loads (such as lamps and LED's) at currents up to 200 mA; but if inductive loads such as relays, buzzers, motors, etc., are used, diodes must be used to protect the IC's output against damage from inductive kick-back, as shown in Fig. 3. Note in the Fig. 3A circuit that the relay load is connected between pin 3 and ground, so the relay is normally off, but is driven on for the duration of the 555 timing period; however, in the Fig. 3B circuit the relay is wired between the positive-supply line and pin 3, and is thus normally on, but turns off for the duration of the timing period.

Relay-output timers are particularly useful, since their relay contacts act as

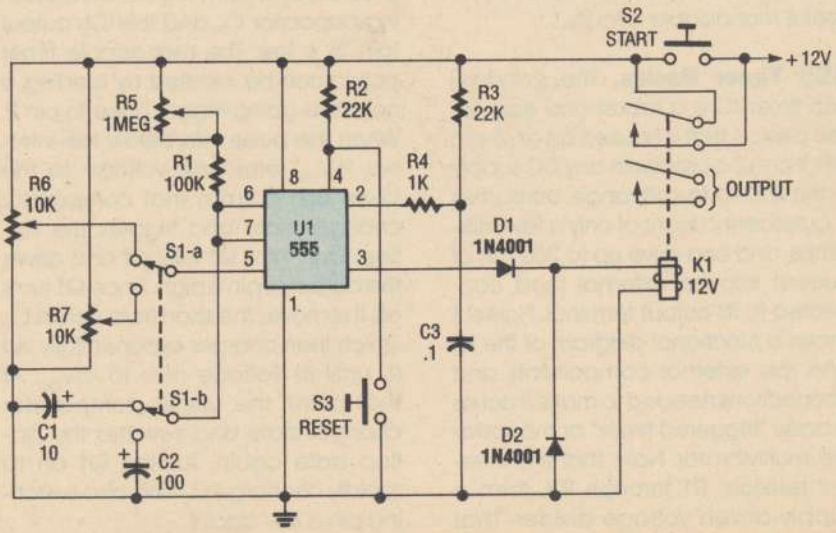


Fig. 4. You can build a precision, two-range (0.9–10 sec, and 9–100 sec) relay-output timer from this schematic.

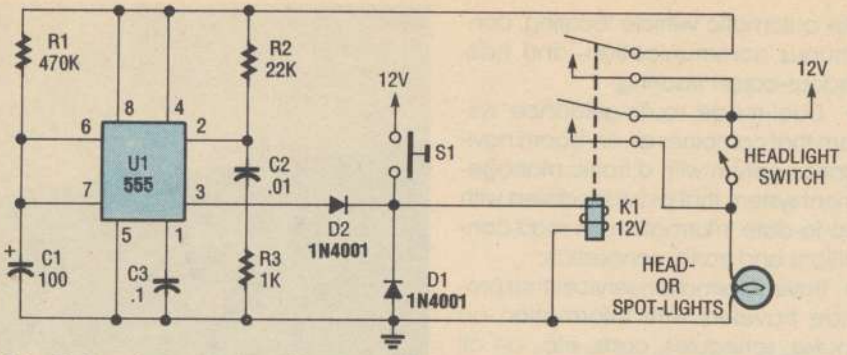
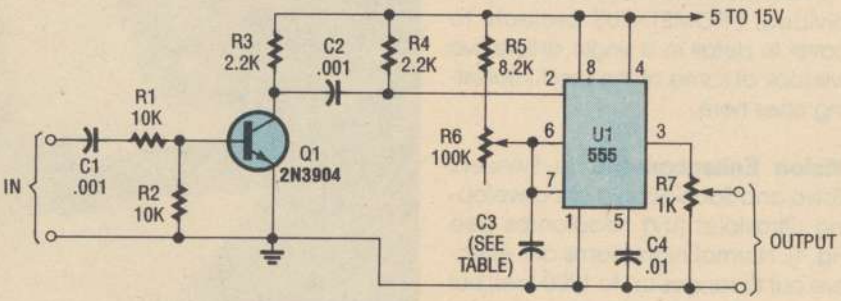


Fig. 5. If you've wanted to add a manually-triggered delayed-turn-off switch to your parking and headlights, check this circuit.



C3 VALUE	PULSE-WIDTH RANGE
10µF	90ms – 1.2sec
1µF	9ms – 120ms
.1µF	900µs – 12ms
.01µF	90µs – 1.2ms
.001µF	9µs – 120ms

Fig. 6. If you have an oscillator that needs an add-on pulse generator then look at this circuit. It is triggered by any rectangular input signal.

fully isolated switches that can be used to apply power to almost any type of external load. Figure 4 shows a relay-output timer that can operate from 0.9 to 100 seconds in two ranges, and uses a relay with two sets of normally-open contacts to prevent consuming any current when it is in the standby mode.

In the circuit, power is initially fed to the timer via S2 when that switch is pressed. That causes C3 (which is initially uncharged) to charge and thus feed a trigger pulse to the 555's pin 2 via R4 to start a timing cycle. That drives relay K1, closing its contacts. The pair of contacts in parallel with S2 short the switch to provide power to the circuit even after S2 is released. At the end of the timing cycle, the relay turns off again and the relay contacts open, thus removing power and disabling the circuit. The relay contacts labeled "output" can be used to control external circuitry or devices.

The circuit's timing is controlled by R1, R5, and either C1 and R6, or C2 and R7, depending on the position of S1. Potentiometers R6 and R7 allow the timing of the two scales to be adjusted so a single calibrated dial can be used for R5 even if wide-tolerance capacitors are used for C1 and C2.

To adjust the circuit, first set R5 to its maximum value, set switch S1 to use R6 and C1, press the start button, and trim R6 to give a timing period of precisely 10 seconds. Next, set S1 to the other position, activate S2, and trim R7 to give a timing period of 100 seconds. At this point, the two ranges are calibrated and you can make-up a dial for R5.

Figure 5 shows a simple variation on the last circuit. It acts as a manually-triggered delayed-turn-off headlight (or spotlight) control system for use in automobiles. It holds the lights on for a pre-set period after the car is parked, thus illuminating a pathway, etc. Since one set of contacts on the relay is in parallel with the car's light switch, the circuit will not interfere with normal headlight operation. The circuit operates so that, if the vehicle has its lights off, they can be turned on for a pre-set 50-second period by momentarily depressing S1.

Pulse Generator Circuits. The 555 can be used as a pulse generator by feeding a pulse-train to pin 2. It can generate good pulses with periods from 5µs and up. Its maximum useful pulse-repetition frequency is about 100 kHz. Of course, the trigger pulses to pin 2 must be negative-going with amplitudes that rise above $\frac{2}{3}V_{CC}$ and fall below $\frac{1}{3}V_{CC}$ (triggering actually occurs as pin 2 drops below $\frac{1}{3}V_{CC}$), and their widths must be greater than 100 ns but less than that of the desired output pulse.

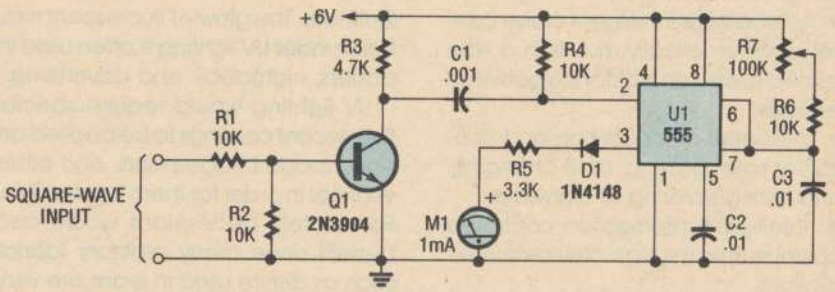


Fig. 7. A simple 1-kHz linear-scale analog frequency meter can easily be built from a 555 timer and some support components.

Figure 6 shows a practical pulse generator that can be used as an add-on to an existing squarewave generator. In the circuit, Q1 will be switched on and off by the incoming squarewave pulses to produce a signal that switches fully between the supply rails. That signal is then differentiated into an appropriate trigger-pulse via the short time-constant network composed of C2 and R4 and the

(Continued on page 85)

SMART FOR SMART

Today, much research is being done on Intelligent Vehicle/Highways Systems (IVHS) technology in the United States. The Europeans have equally ambitious projects to put smart vehicles on smart highways in Europe.

Just about every major European automaker is participating in the PROgraMme for a European Traffic with Highest Efficiency and Unprecedented Safety, or PROMETHEUS for short. Many European automotive component suppliers, research institutes and universities are also involved.

The PROMETHEUS program is aimed at making the entire European transportation infrastructure safer, more efficient and friendlier to the environment. Foremost, are projects that will make driving safer such as:

- Vision enhancement for driving at night and in poor weather.
- Proper vehicle operation using advanced technology to make both cars and drivers safer.
- Collision avoidance, probably the first important use of IVHS technology that will hit the market.

Another important part of PROMETHEUS is traffic-flow harmonization to decrease the effects of traffic congestion, accidents, driver stress, wasted energy, and pollution. Projects along those lines include:

- Autonomous intelligent cruise control to automatically maintain a safe relative speed and distance between vehicles.
- Intelligent maneuvering and control for safer passing, lane changing, and exiting/entering of highways.
- Intelligent intersection control to optimize flow through crowded intersections.
- Medium-range pre-information to provide drivers with information about situations beyond the range of direct vision and perception.
- Emergency warnings that automatically summon emergency services to an accident and help prevent mass collisions.

As we said, PROMETHEUS is aimed at improving the entire European transportation system, so another area of research it affects is travel and transport management by promising the following systems:

- Commercial-fleet management to assist truckers through techniques like automatic vehicle locating, continuous communication, and hazardous-cargo tracking.
- Dual-mode route-guidance system that combines an on-board navigation system with a traffic management system that provides drivers with up-to-date information on road conditions and traffic congestion.
- Travel information services that provide travelers with information on routes, schedules, costs, etc., on all available means of transportation to get from point A to point B.

Since there are really too many individual PROMETHEUS projects to cover in detail in a single article, we will look at some of the most interesting ones here.

Vision Enhancement. In Sweden, Volvo and Saab-Scania are developing ultraviolet (UV) headlamps (see Fig. 1). Normal highbeams are effective out to ranges up to 1000 feet, but because they can blind oncoming drivers, they cannot be used in heavy traffic. Ultraviolet lights would be invisible to oncoming traffic and would be used with low beam headlamps to extend visibility out to as far as 500 feet. When UV lights, operating at shorter wavelengths (100–400 nm) than ordinary visible light, strikes a fluorescent material, it triggers a physical process that makes the material luminous. The glow of fluorescent material under UV lighting is often used in posters, nightclubs, and advertising.

UV lighting would require special fluorescent coatings to be applied on signs, roads, bridge pillars, and other vehicles in order for them to be visible. Fortunately, pedestrians would also benefit since many ordinary fabrics such as denim used in jeans are very

visible in UV light. UV light in the 315–400-nm region of the light spectrum would be used since UV at lower wavelengths has been shown to cause aggressiveness, which is not exactly a desirable trait to have while driving.

Ultraviolet illumination does not work on the principle of reflection like normal light. Instead the flourescent material emits light of its own when exposed to UV light. Therefore, the "white-wall" effect in fog, mist, snow, and rain does not occur. Ultraviolet lighting is also relatively insensitive to external disturbances such as frost, temperature, moisture, dirt, snow, etc. For example, fluorescent road signs could still be visible under UV light even when hidden by frost or a light covering of snow.

So far, results are promising with visibility ranges at least double that of ordinary headlights. If applied properly, motorists would be assured of better visual information, but without resorting to dazzling each other. Solving legal problems needed for widespread use of this technique could be the greatest hurdle.

Other vision-enhancement projects are investigating more sophisticated ways to enhance vision. For example, in France, Renault, PSA, and Matra are using headlights that operate in the near-infrared (IR) wavelengths for improving visibility at night and under other low-contrast conditions. The scene illuminated by these IR headlights would be viewed by a CCD camera mounted on the windshield (see Fig. 2). After image and data processing, the image is presented to the driver on an instrument-panel mounted display.

In England, Jaguar is using thermal

CARS HIGHWAYS

Learn about the exciting new technology that promises to make driving safer and more efficient.

BY BILL SIURU

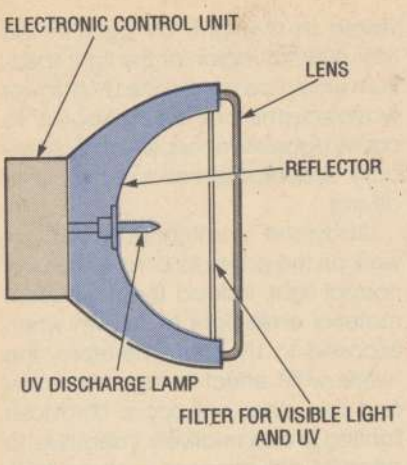


Fig. 1. Filters are key technology items required to make UV headlamps practical. For example, filters must filter out visible and low wavelength UV light that can cause biological aggressiveness.

projects the sensor's image onto a holographic combiner screen placed in front of the windshield using lights, filters, optical lenses, and a spatial light modulator.

Proper Vehicle Operation. There are many separate PROMETHEUS projects designed to make driving safer under changing road conditions, or when sudden, adverse changes occur in either the condition of the vehicle or the driver. Other research projects are aimed at reducing driver workload especially during stressful driving conditions.

Volkswagen is developing a visibility monitor that uses the backscatter from an IR-laser range finder to measure the instantaneous visibility range. These measurements are used to recommend a safe speed for these conditions. BMW's "LIFE- Vehicle-Status Monitor" detects and predicts impending individual component failures that could affect safety. Ford of Europe is working on monitoring the driver's psychological condition to alert a driver when he or she is not ready for a hazardous situation if one should arise. Volkswagen and Porsche are measuring the actual friction between road and tires. The measurements are then compared against the required friction for good traction under the current road and driving conditions and the driver is warned if the traction is below a safe level.

Several automakers are looking at advanced control techniques for increasing safety. Fiat's "Active Camber-Angle Control" adjusts the camber angles of the rear wheels to optimize road adherence for better directional stability and higher maneuvering limits. Saab replaces the steering wheel with a fighter-like sidestick controller, or joystick, in its "Driver Assisting Copilot-Steering" concept. The sidestick controller's location allows an unobstructed view of the instrument panel. The lack of a conventional steering wheel eliminates a major crash-safety hazard and makes it easier to install the driver-side airbag. Also like modern fighters, Saab uses a "fly-by-wire" (actually "steer-by-wire") system where mechanical linkages, hydraulic lines, and actuators are replaced by wires and motors. Saab's computer-aided active steering filters out unwanted road disturbances and irrelevant feedback to the driver. It could also be adaptable to varying driving conditions and even different drivers.

Other proper vehicle-operation projects are aimed at eliminating the danger when, for example, a driver wanders out of his or her lane. Besides just detecting and warning, systems separately designed by BMW, Matra, and PSA would actively intervene if the driver did not heed the warning.

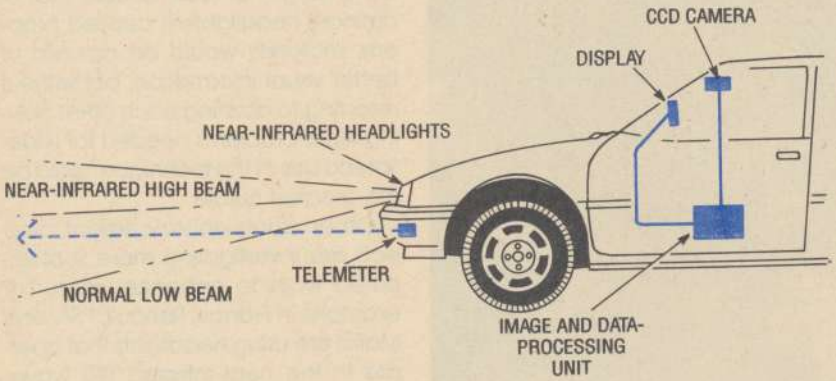


Fig. 2. Near-IR vision-enhancement systems require IR headlamps to illuminate the road ahead, a CCD camera to view the scene, plus image processing before it can be displayed to the driver.

imaging in the far-IR wavelengths. Here, IR images resulting from differences in the thermal radiation emitted by all objects are captured by an IR-sensitive camera and thus special headlights are not needed. Italy's Fiat is investigating a "Gate Intensified Camera" system. In it, a light-pulse generating headlamp illuminates objects ahead of the car. The gate intensified camera views the reflected pulsed light to improve long distance visibility especially at night or in fog.

An important part of vision enhancement are the heads-up-displays, or HUD's, that would overlay the image obtained by an IR camera or other vision-enhancement sensor over the driver's normal view of the road (see Fig. 3). For example, Fiat and Renault are developing a HUD that

Autonomous Intelligent Cruise Control. For over a year, Mercedes-Benz has been testing a 300E sedan equipped with autonomous intelligent cruise control. It uses a hood-mounted, five-ray infrared-sensor system. Distance and relative speed between the 300E and the preceding vehicle are determined by measuring the time it takes for IR signals emitted by the sensor's transmitter to be reflected off the other vehicle and received by the sensor's receiver. Measurements are constantly transmitted to an on-board computer via fiber-optic cables. The computer sends commands to actuators that move the accelerator, throttle valve, and brakes. Commands are also sent to the automatic speed controller and the automatic transmission.

The sensors monitor a distance of up to 150 meters (500 feet) on a straight stretch. The shortest distance is five meters (16 feet). Like regular cruise control, the driver sets the desired top speed via the cruise-control switches. Unless the driver specifies otherwise, the car in front will be followed at the legal distance computed from the speed setting. If the

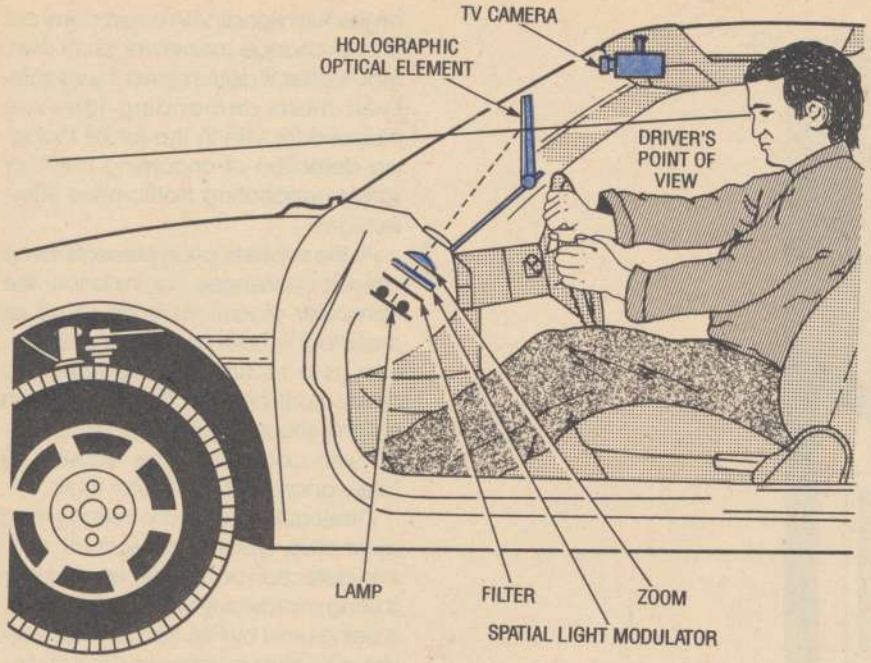


Fig. 3. A typical heads-up display that would present the scene captured by a vision-enhancement sensor superimposed over the driver's normal view through the windshield.

Mercedes-Benz uses a van filled with computer gear and three video cameras in its computervision "Vision Technology Applications" demonstration program.

distance becomes less or greater, the car will brake or accelerate like an experienced driver would. An alarm sounds if there is a very large speed difference with respect to the preceding vehicle. When the vehicle in front turns off the road, the system automatically switches over to normal cruise control. When another vehicle moves in front, distance control is resumed. In all cases, the driver has final control and can override the system at any time by touching the brake or accelerator pedal.

The AICC's computer software uses sophisticated algorithms to distinguish between vehicles or obstacles in the pathway and roadside objects. Objects detected and distances measured by the middle IR channel are given priority with the reflection from the roadside objects mainly ignored.

While using the same basic logic, several other manufacturers are using different sensing techniques for their automated intelligent cruise-control systems. For instance, PSA and Renault are using a single-beam IR-sensor and IR-laser scanner respectively. Matra's system incorporates a CCD-based telemetric sensor, while Volvo and Saab are employing a transponder. The bottom line is that AICC can relieve stress and allow drivers to concentrate better on traffic. Because it automatically closes the gap between vehicles, traffic flow is improved and highways could handle even more traffic.

Collision Avoidance. Collision avoidance combines many of the concepts found in vision enhancement, automated intelligent cruise control, and proper vehicle operation. The whole idea here is to prevent, or at least mitigate, accidents by detecting other vehicles and obstacles in time for the driver to take appropriate action to avoid an accident. Or the vehicle could even maneuver automatically. Several automakers are developing collision-avoidance systems, the main difference between approaches are in the types of sensors used to detect vehicles and obstacles. Most systems use several sensors to acquire information on the driving environment. Sophisticated computer algorithms are used to interpret and evaluate the situation, and then for assessing and prioritizing the potential collision threat. The threat is reduced either by warning the driver or, if there is insufficient time for the driver to react, by computer commands to actuators and motors to provide instantaneous intervention.

Computervision is one popular approach that is being used by BMW, Daimler-Benz, Jaguar, Renault, and PSA. For example, Daimler-Benz has fitted out a Mercedes-Benz van as a testbed for its Vision Technology Application, or VITA, project. The van is filled with computers and other electronic equipment, plus three video cameras. The two cameras in the front window view the path ahead and one in the rear window captures the scene behind. The cameras are equipped with telephoto and wide-angle lenses. The images are displayed on a monitor located in the instrument panel.

VITA's software first discriminates between important and unimportant data. Then it uses the remaining information to compute parameters like distances to the road edges, approaching obstacles, preceding vehicles, and road topology such as its radius of curvature. The information is digested and analyzed by more software to produce warnings, instructions for the driver, or commands given directly to servomechanisms that steer, accelerate, or brake the van.

VITA provides information on several levels, the simplest merely assists in maintaining safe distances in stop-and-go traffic and safe speeds for road conditions, or for help when parking. More complex functions include warning or automatic intervention if the vehicle veers out of its lane should the driver "nod off." By flipping

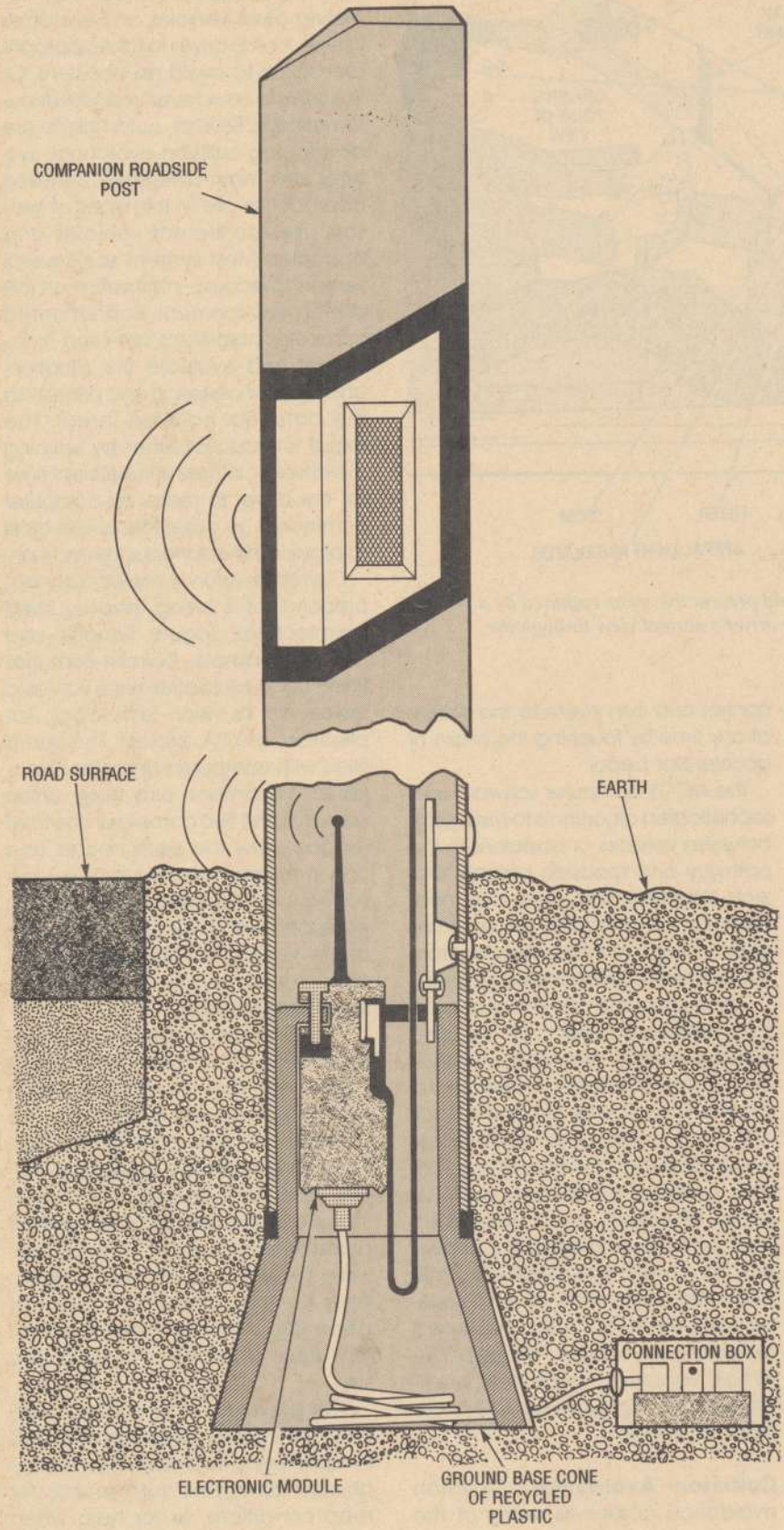


Fig. 4. BMW's Companion roadside warning and information system looks like a regular road marker. However, inside is a small radio transmitter/receiver used to communicate with individual cars and lights that flash to provide a warning to other drivers in case of an emergency situation ahead.

on the turn signal, VITA could carry out a lane-change maneuver on its own, that is after it determined it was safe. Even more demanding jobs are planned for VITA in the future including detection of oncoming traffic or safely negotiating traffic-filled intersections.

All this sophistication presents some difficult challenges. For instance, the computer algorithms have to be as proficient in both analysis and execution as a reasonably experienced driver. Furthermore, the automated systems should not replace human error with computer error caused by faulty analysis or computer logic.

Other automakers are investigating alternative types of sensors for collision detection and prediction. Jaguar is using microwave radar while "LIDAR" is being used by Fiat, Renault, and PSA. Volvo is using a transponder system.

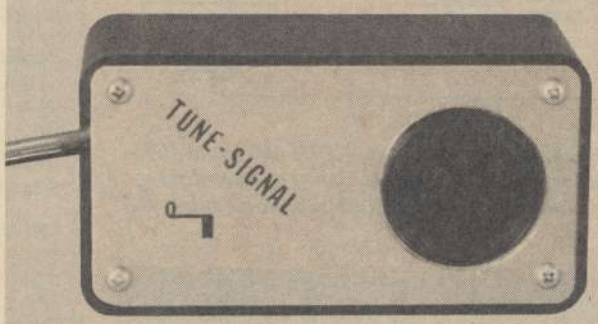
Collision avoidance will take longer to bring to market than other IVHS technology because of the complexity of the task, though elementary systems such as blind-spot detection and ones for stop-and-go driving could start appearing as options quite soon. According to Mercedes-Benz, "autopilots, which is [sic] now taken for granted in aviation, will never become a reality in road transport, since there will always be situations in which the decisions must be left to the driver." Because of that, driver-assistance systems like VITA will continue to give the driver the final responsibility for decisions.

Emergency Systems. If accident avoidance fails, emergency systems are then needed to minimize the consequences of an accident. Two basic types of actions are required to reduce the devastating consequences of a major highway accident and prevent the emergency from becoming even more serious: First, quick response from emergency-service vehicles to minimize injuries and save lives. Second, other approaching vehicles must be warned to protect the accident site and prevent further collisions.

BMW's prototype COMPANION system performs both emergency-call and emergency-warning functions, plus a few more jobs. At the heart of COMPANION are roadside posts (see

(Continued on page 98)

BUILD A TURN-SIGNAL REMINDER



BY JIM STEPHENS

If you often neglect to turn off your car's turn signal, then perhaps this easy-to-build reminder is just what you need!

Have you ever merged onto an interstate highway from an on ramp and several miles down the road realized that your turn signal never went off as you entered traffic? Suddenly, you realize that there are 16 cars slightly behind you in the left lane that have been refusing to pass for several miles, fearing that you may really intend to change lanes. You turn off the signal, and as those vehicles fly past you, their drivers give you a look that, as they say, could kill!

Well, the *Tune-Signal* described in this article—which is designed to set off a musical chime—will prevent that from happening by alerting you when your signal has been left on a little too long. The circuit uses a small, inexpensive, pleasant-sounding, musical chime, rather than an irritating buzzer; you probably already have enough irritation while drive without adding more irritation to it.

About the Circuit. A schematic diagram of the Tune Signal is shown in Fig. 1. The circuit consists of U1 and U2 (a 4093 quad two-input NAND Schmitt trigger and a 4040 12-stage ripple-carry counter/divider, respectively), Q1 (a TIP42 PNP silicon power transistor), BZ1 (the aforementioned chime module), and a handful of support components.

The input to the circuit—a series of pulses plucked from the load (or output) wire of the auto's flasher module—immediately divides along two signal paths. In one path, the signal is applied to gate U1-d, which is configured as an inverter. The output of that gate is fed through diode D1 and used to charge C2, a 470-µF capacitor. The charge on C2 is applied to both inputs of U1-c (also set up as an inverter), pulling its output low, in effect, enabling U2.

In the second path, the signal is fed to U1-a, which squares the applied signal in preparation for its application to the clock input of counter U2. The squared-up pulses applied to U2's clock input cause the counter to advance one count for each clock pulse received. When both pins 3 and 4 (the Q5 and Q7 outputs, respectively) are high at the same time, the output of U1-b is pulled low. That low is applied to the base of Q1, causing the transistor to turn on. With Q1 turned on, power is applied to the chime module (BZ1), causing it to sound. The chime module—which puts out enough volume to be heard over the road noise—will chime twice, wait a few seconds and chime again if the circuit is not reset.

After the chime has sounded, and the turn signal is switched off, the charge stored in C2 is bled off through R3. With C2 no longer charged, the output of U1-c goes high, resetting U2. When U2 is reset, its outputs (at pins 3 and 4) go low. That low, which is applied to the base of the transistor, causes Q1 to turn off, removing power from the chime module.

The number of flashes that the circuit counts depends on which two of U2's outputs are connected to U1-b. With the circuit wired as shown in Fig. 1, about 70 flashes are allowed to occur before the chime sounds. The number of flashes that the counter counts before triggering the chime can be altered by connecting pin 6 of U1-c to another of U2's outputs. For example, connecting pin 13 (the Q7 output) of U2 to pin 6 of U1-b, rather than to pin 4, directs the circuit to count 144 flashes before sounding the chime. Even greater counts can be achieved by connecting to the higher Q outputs (say, the Q11 and Q12 outputs, at pins 15 and 1, respectively) of U2 to pins 5 and 6 of U1-b.

Power for the circuit is taken from any keyed (switched) power line at the vehicle's fuse panel, so that the circuit receives power only when the ignition key is in the on position. Fuse F1 is included in the circuit in case of a wiring error or short.

Circuit Assembly. The author's prototype of the Tune Signal was hard-wired on a small section of perfboard. Use Fig. 1 as a guide when assembling your unit. It is recommended that sockets be provided for the two integrated circuits (U1 and U2). That will prevent thermal damage to the IC in the event that a component is misconnected to an IC pin. The IC's, being CMOS units, are highly susceptible to damage due to heat and electrostatic discharge.

The chime module (BZ1) was not mounted to the perfboard along with the other components, but was instead mounted to the front panel of the enclosure in which the circuit was housed. You could, however, mount the chime module remotely in some other position that allows it to be heard. The circuit was housed in a small plastic enclosure with a metal lid. The only enclosure preparation required is to make a hole (or slot) in the enclosure for the wires that connect the circuit to a keyed (switched) 12-volt power source, ground, and the flasher's load wire, and (as appropriate) a cutout for the chime module or a second hole for the connecting wires between the circuit and a re-

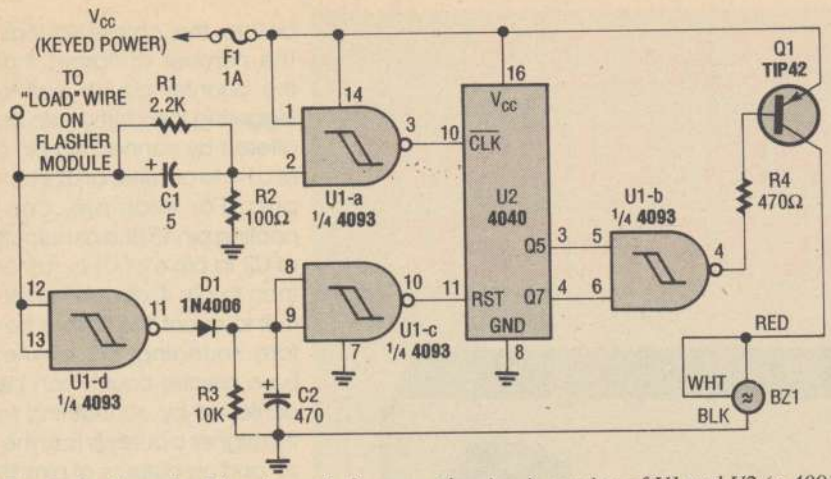
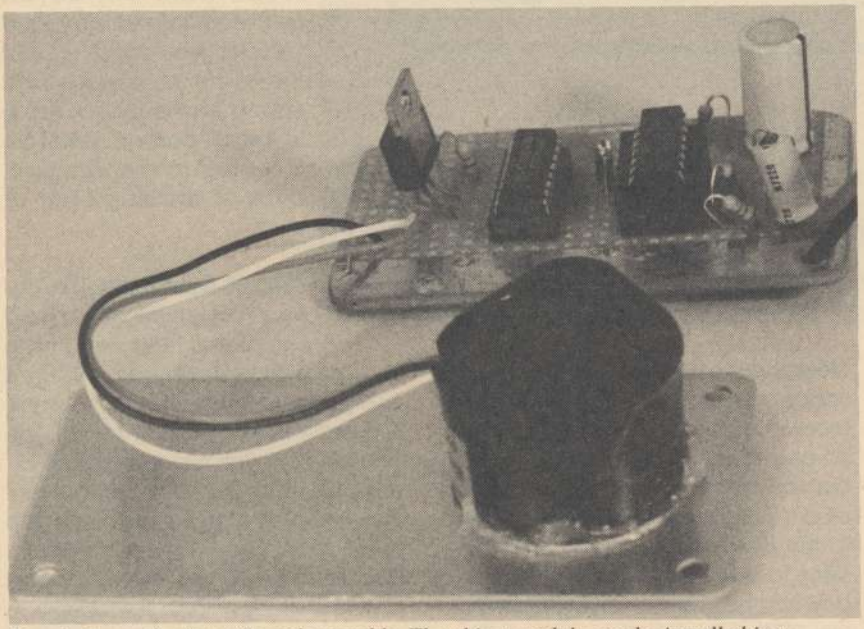


Fig. 1. As shown by this schematic diagram, the circuit consists of U1 and U2 (a 4093 quad two-input NAND Schmitt trigger and a 4040 12-stage ripple-carry counter/divide, respectively), Q1 (a TIP42 PNP silicon power transistor), BZ1 (the chime module), and a handful of support components.



Here is the author's perfboard assembly. The chime module can be installed in a cutout in the front panel of the enclosure, and secured in place with silicon cement, as shown here, or mounted remotely in some other convenient location within earshot.

Here's the completed unit just prior to installation.

motely located module.

Note that fuse F1 (a fast-blow unit) is not mounted to the circuit board, but is instead an in-line unit that should be connected to the far end of the circuit's power-supply line (near the +V feed point) to minimize the chance that a short could occur between the fuse and the connection.

Installation. The first step in installing the circuit is to locate the vehicle's flasher module. Connect the project's positive-supply line to a switched power source (the 12-volt power line that feeds the flasher module is ideal) and the negative line to ground (preferably somewhere on the chassis). Then connect the Tune Signal's input wire to the load (or output) of the vehicle's turn-signal flasher module. The signal and power connections can be simplified by using small "self tap" snap connectors.

To test the operation of the circuit simply turn the vehicle ignition on, and activate the turn signal (any direction will do). After a predetermined number of flashes, the circuit should activate the chime. Let the turn signal remain on for a while. The module will chime, wait a few seconds, and the unit should chime again if the circuit is not reset. If the circuit works as outlined, you can turn off the turn signal, and mount the unit near the bottom of the dash so that sound will be directed into the car and not up into the dashboard. The author used Velcro fasteners to attach the unit to the underside of the dash. That allows the project to easily be removed should it become necessary to service the unit.

That's all there is to it. Once the Tune-Signal is intalled, you and your fellow drivers should enjoy safer and saner motoring. ■

PARTS LIST FOR THE TUNE-SIGNAL

SEMICONDUCTORS

U1—4093 quad 2-input NAND Schmitt Trigger, integrated circuit
U2—4040 12-stage, ripple-carry, binary counter/divider, integrated circuit
Q1—TIP42 PNP silicon, power transistor
D1—1N4006 1-amp, 800-PIV, rectifier diode

RESISTORS

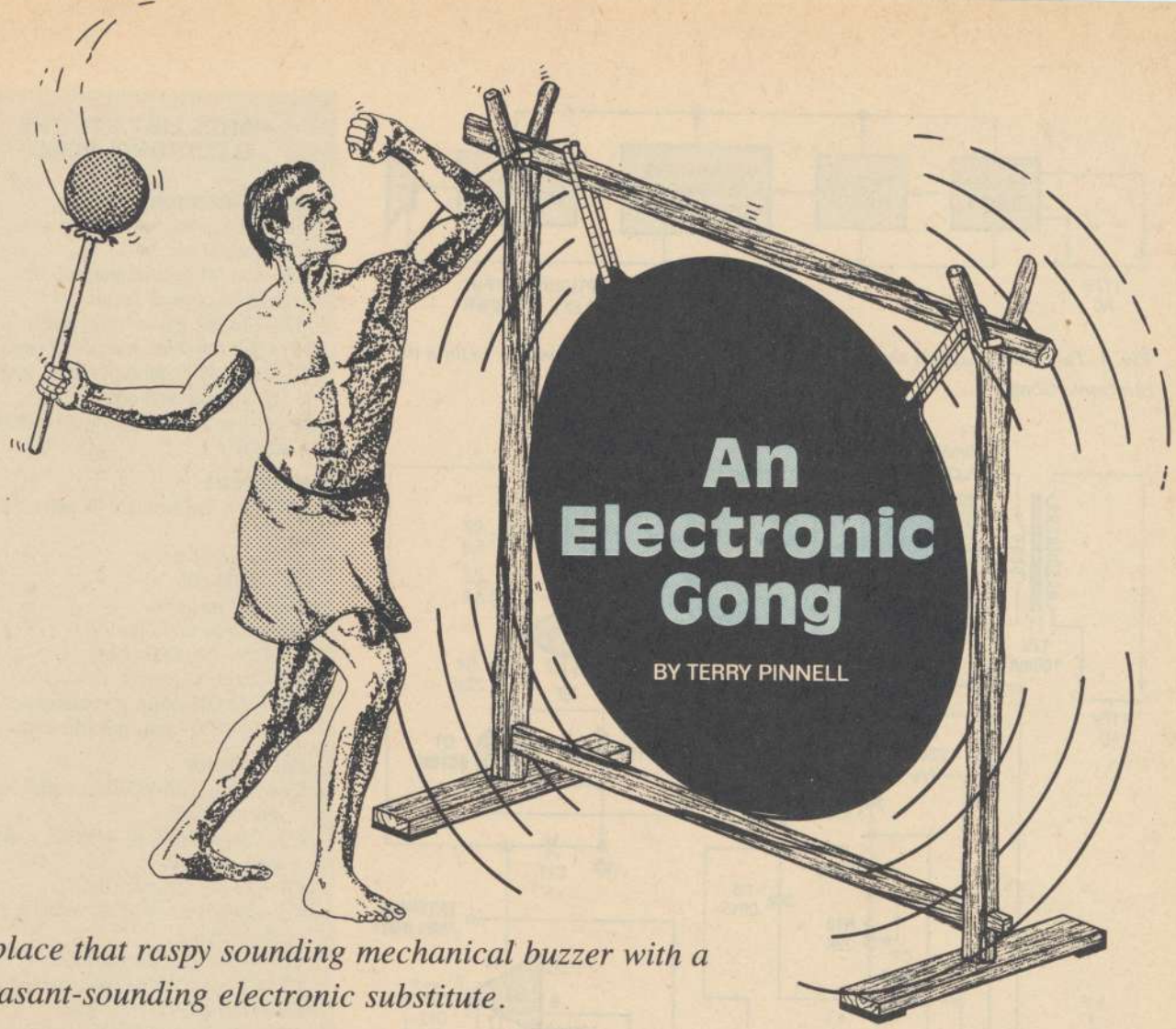
(All resistors are ⅛-watt, 5% units.)
R1—2200-ohm
R2—100-ohm
R3—10,000-ohm
R4—470-ohm

CAPACITORS

C1—5-μF, 25-WVDC, electrolytic
C2—470-μF, 25-WVDC, radial lead electrolytic

ADDITIONAL PARTS AND MATERIALS

F1—1-amp, fast-blow fuse
BZ1—Chime module (Radio Shack 270-071)
Perfboard materials, enclosure, in-line fuse holder, snap-on connectors, wire, solder, hardware, etc.



An Electronic Gong

BY TERRY PINNELL

Replace that raspy sounding mechanical buzzer with a pleasant-sounding electronic substitute.

I was awakened one morning for the *umpteenth* time by the loud rasping noise produced by our bedside tea-making machine. My wife and I would hate to be without our morning resuscitator. However, I thought that it deserved a more civilized sounding device than an electro-mechanical buzzer. So, I decided to replace it with a less crude alternative—the *Electronic Gong* described in this article.

Circuit Operation. Figure 1 shows a block diagram of the Electronic Gong, which is comprised of a power supply, an oscillator, an active filter, and an audio-output amplifier.

Figure 2 shows a full blown schematic diagram of the Electronic Gong. Power for the circuit is provided by a 12-volt stepdown transformer (T1) coupled with a fullwave bridge rectifier (BR1). The power supply provides a non-critical DC voltage, which is filtered by capacitor C1, and is used to power the rest of the circuit.

Application of power causes an asymmetrical astable multivibrator or oscillator (formed around U1-a and U1-b) to begin generating pulses. Resistor R1 is included in the oscillator circuit to minimize voltage dependency. Components R2 and D1 provide a fast alternative discharge path, causing the circuit to produce a series of very sharp output pulses, about 12 seconds apart.

One requirement of simple CMOS astables is that the timing capacitor be non-polarized. For short periods that's not a problem, since the value of capacitance would be low (*e.g.*, below 1 µF). The timing period (T) in seconds is roughly equal to 0.7RC, where R is resistance in megohms and C is capacitance in microfarads. That means that the capacitance would have to be about 1.4T/R.

Unfortunately, for periods of more than, say, 5 seconds, with the value of R kept below 5 megohms, the value of the timing capacitor would have to be greater than 1.4 µF. That would normally call for an electrolytic unit. However, that problem is easily circumvented by using a pair of equal value, back-to-back electrolytics in series (C2 and C3 in Fig. 2). That produces an effective capacitance that's half the value of the individual units, while at the same time, doubling the effective voltage rating; in effect, the voltage ratings of the two units are additive. (Incidentally, the capacitors do not have to be equal in value, however, equal values make the calculation simple.)

For any two values given C2 and C3, the resulting capacitance is calculated like resistors in parallel, from 1/C = 1/C1 + 1/C2. (That can also be quite a handy dodge when you have no capacitor on hand with a high enough voltage rating; just use two back-to-back units and treat the result as having twice the rating.)

The output of the oscillator (at pin 4 of U1-b) is coupled via C4 to the base of Q1 (a BC108 NPN silicon transistor), causing it to briefly conduct. With Q1

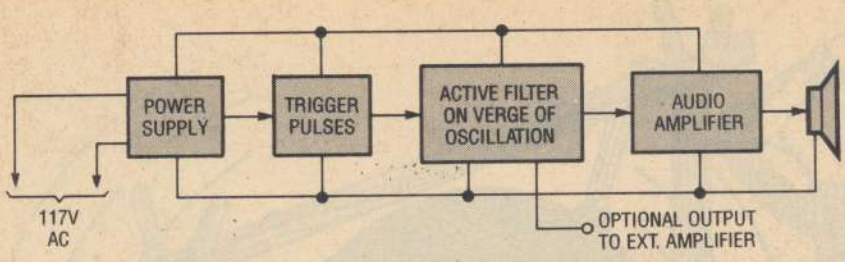


Fig. 1. This block diagram shows the various subassemblies that combine to form the Electronic Gong.

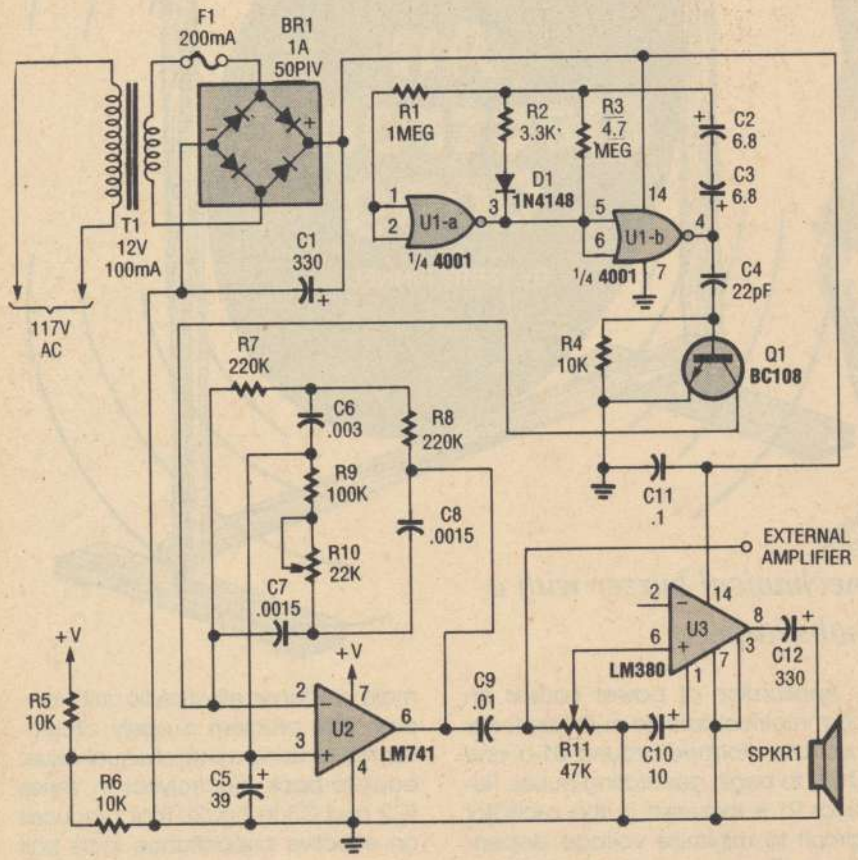


Fig. 2. The Electronic Gong is comprised of a power supply (made up of a 12-volt stepdown transformer coupled with a fullwave bridge rectifier), an oscillator (built around half of a 4001 quad 2-input NOR gate), an active twin-T filter (built around an LM741), and an audio-output amplifier (consisting of an LM380 low-voltage audio-power amplifier).

PARTS LIST FOR THE ELECTRONIC GONG

SEMICONDUCTORS

U1—4001 quad 2-input, NOR gate, integrated circuit
U2—LM741 general-purpose op-amp, integrated circuit
U3—LM380 low-voltage, audio-power amplifier, integrated circuit
D1—1N4148 general-purpose, small-signal, silicon diode
BR1—1-amp, 50-PIV, fullwave-bridge rectifier

RESISTORS

(All fixed resistors are ¼-watt, 5% units.)
R1—1-megohm
R2—3300-ohm
R3—4.7-megohm
R4–R6—10,000-ohm
R7, R8—220,000-ohm
R9—100,000-ohm
R10—22,000-ohm, potentiometer
R11—47,000-ohm, potentiometer

CAPACITORS

C1—330-µF, 16-WVDC, radial-lead electrolytic
C2, C3—6.8-µF, 10-WVDC, radial-lead electrolytic
C4—22-pF, ceramic-disc
C5—39-µF, 10-WVDC, radial-lead, electrolytic
C6—0.003-µF, polystyrene
C7, C8—0.0015-µF, polystyrene
C9—0.01-µF, ceramic-disc
C10—10-µF, 16-WVDC, radial-lead electrolytic
C11—0.1-µF, ceramic-disc
C12—330-µF, 16-WVDC, electrolytic

ADDITIONAL PARTS AND MATERIALS

T1—12-volt, 100-mA, stepdown transformer
F1—200-mA PC-mount fuse
SPKR1—Speaker, see text
Perfboard materials, enclosure, AC power source, IC sockets, grommet, stand-offs, wire, solder, hardware, etc.

conducting, pin 2 of U2—a 741 general-purpose op-amp, which forms the heart of the active twin-T filter circuit—is pulled close to ground which is all that is needed to strike the gong.

The twin-T filter configuration, see Fig. 3, is normally used as the basis for notch filters (or sometimes as a sine-wave generator). In our application, however, the filter it is set up to be on the threshold of oscillation. In the twin-T circuit, two separate T-filter elements—lowpass (Fig. 3A) and highpass (Fig. 3B) filters—combine to produce a bandpass filter. Figure 3C shows the basic configuration for the twin-T filter used in the Electronic Gong. Also shown in that figure is the relationship between the components values of the two filter elements. The bandpass frequency of the circuit is given by:

$$f = \frac{1}{2\pi RC}$$

where f is frequency in Hz, R is resistance in ohms, and C is capacitance in farads.

Table 1 gives the bandpass frequency of the filter network base on a fixed capacitance (in our case, 1500 pF) and various resistor values. For example, if you want to try for a bass-drum sound, you might try replacing R7 and R8 (220k, respectively) with 1-megohm (1000k) resistors. You would additionally have to alter the values of R9 and R10 so that their combined resistance could be adjusted to about 500k; that could probably be best achieved by making R9 a fixed 470k unit and presetting R10 to 47k. (Natu-

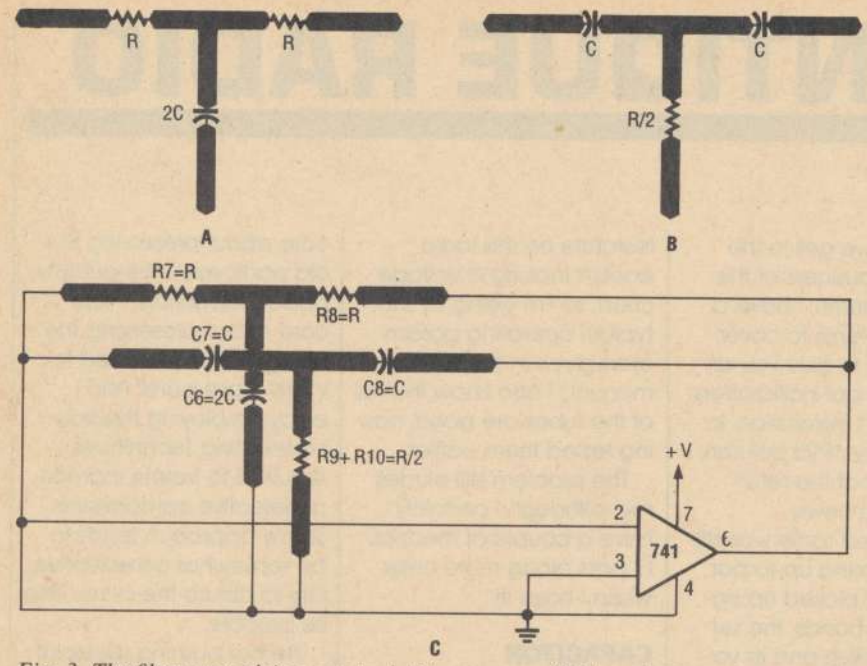


Fig. 3. The filter network is comprised of two separate T-filter elements—lowpass, A, and highpass, B, filters—which combine to produce a bandpass filter. The basic configuration for the twin-T filter used in the Electronic Gong is shown in C. Also shown is the relationship between the components values of the two filter elements.

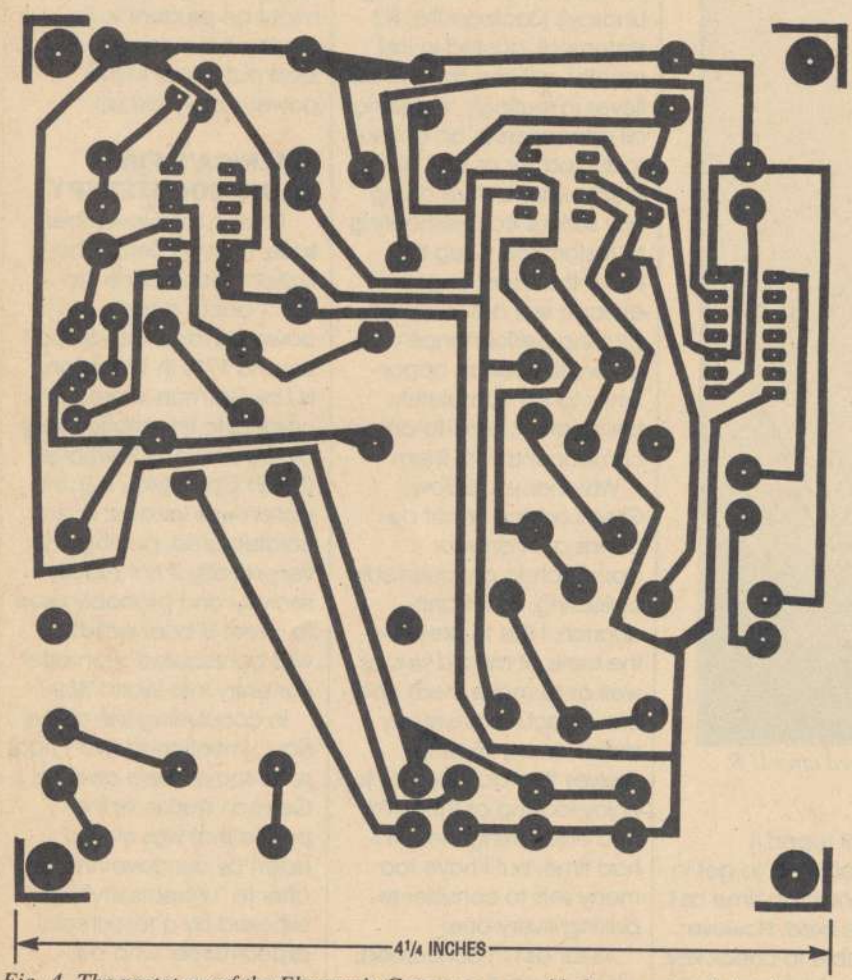


Fig. 4. The prototype of the Electronic Gong was assembled on a printed-circuit board, measuring approximately 4¼ by 4¹⁰⁄₁₆ inches. Here's a template of that foil pattern.

TABLE 1—BANDPASS FREQUENCY RANGE

Resistance (k ohms)	Capacitance (pF)	Frequency (Hz)
47	1500	2260
56	1500	1890
100	1500	1060
180	1500	590
220	1500	480
390	1500	270
470	1500	230
560	1500	190
680	1500	160
1000	1500	110
1200	1500	90

rally, if you are using a miniature speaker as specified in the basic circuit, then don't expect it to do justice to your drum.)

The output of the twin T-filter circuit (at pin 6 of U2) is fed to the inverting input of U3 (an LM380 audio power amplifier) at pin 6 through C9 and the wiper of R11 (which serves as a volume control). Any speaker impedance of greater than 8 ohms is suitable and its selection is mainly a question of what maximum volume you need; the lower the speaker's impedance, the louder the output at any given R11 setting. The author used a 64-ohm unit in his prototype.

Construction. The author's prototype of the Electronic Gong was assembled on a printed-circuit board, measuring approximately 4¼ by 4¹⁰⁄₁₆ inches. A template of that foil pattern in shown in Fig. 4. Once you've etched your printed-circuit board and gathered the parts construction can begin.

A parts-placement diagram for the author's printed-circuit layout is shown in Fig. 5. It is recommended that sockets be provided for the IC's. For the most part, the component values are not critical; the only exception is that the twin-T resistors (R7 and R8) and capacitors (C7 and C8) are within at least 5% of each other. Note that in the area of C2 and C3, the author has provided extra pads to accommodate capacitors slightly larger than the subminiature units used in the prototype.

Begin construction by first installing the IC sockets, followed by the passive components. Afterwards, install all

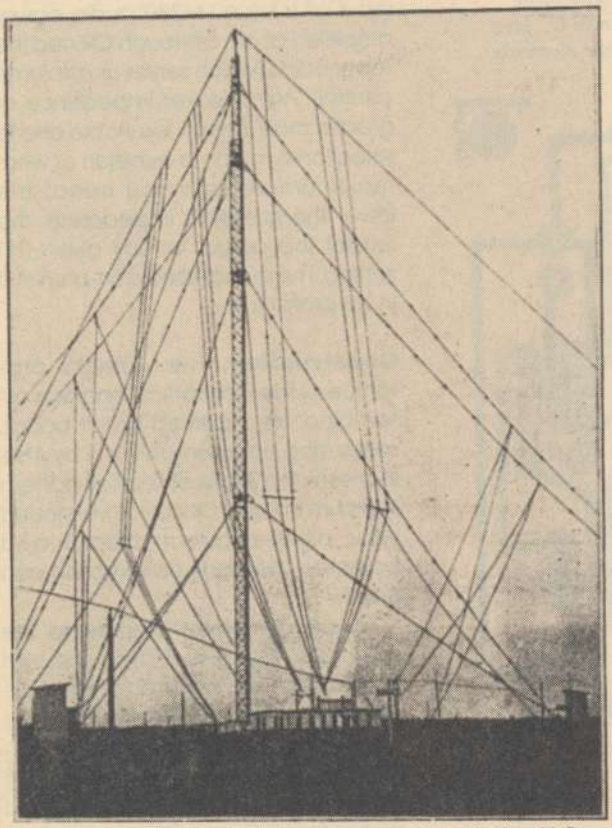
(Continued on page 94)

ANTIQUE RADIO

By Marc Ellis

Electronic Espionage—World War I Style

Before we get to the main business of this month's column, I have a couple of items to cover. First, I'd like to give you an update on our Hallicrafters "Sky Buddy" restoration. In the January, 1993 column, I reported that the refurbished and newly-reassembled radio was still not performing up to par. Although it picked up signals on all bands, the set was insensitive and its volume was quite low.



Part of Sayville's antenna structure, as enlarged after U.S. seizure in 1915.

Since that report, I haven't been able to get in as much workshop time as I would have liked. However, I've been able to check key voltages at all tube sockets, and they appear to be normal. (The *Rider's Manual* literature on this radio doesn't include a voltage chart, so I'm going by the typical operating parameters given in the RCA tube manual.) I also know that all of the tubes are good, having tested them earlier.

The problem still eludes me, although I certainly have a couple of theories. I'll pass along more news when I have it!

CAPACITOR CONTROVERSY

The other thing I want to be sure to do this month is to respond to reader Greg Lindsay's (Jacksonville, FL) statement, quoted in last month's column, that he believes in routinely replacing all capacitors in an antique radio (paper as well as electrolytic) before doing any serious troubleshooting or restoration. Greg believes that most caps in antique sets are leaky, degrading performance and just waiting for an opportunity to fail completely, taking other, hard-to-obtain components with them.

Whether you follow Greg's advice or not depends a lot on your approach to antique-radio collecting. As an antiquarian, I like to preserve the looks of my old sets as well as to make them operate. In fact, I have many radios on my display shelves that don't work; I just enjoy looking at them. I'd also enjoy fixing them if I had time, but I have too many sets to consider repairing every one.

As far as I'm concerned, what's under the chassis is as important in how a set looks as what's outside. I care about preserving the old parts, even the gummy paper capacitors. I also care about preserving the wiring techniques used to install those parts. And I enjoy employing the troubleshooting techniques required to isolate individual defective components. So my approach tends to be somewhat conservative; I try to disturb the set as little as possible.

I'm not pushing my point of view, just telling you how I feel. Of course, if you plan to operate one of your old sets quite regularly, it really might be prudent to replace all the caps, or at least put a fuse in the power-supply circuit!

AMERICA'S FIRST RADIO COUNTERSPY

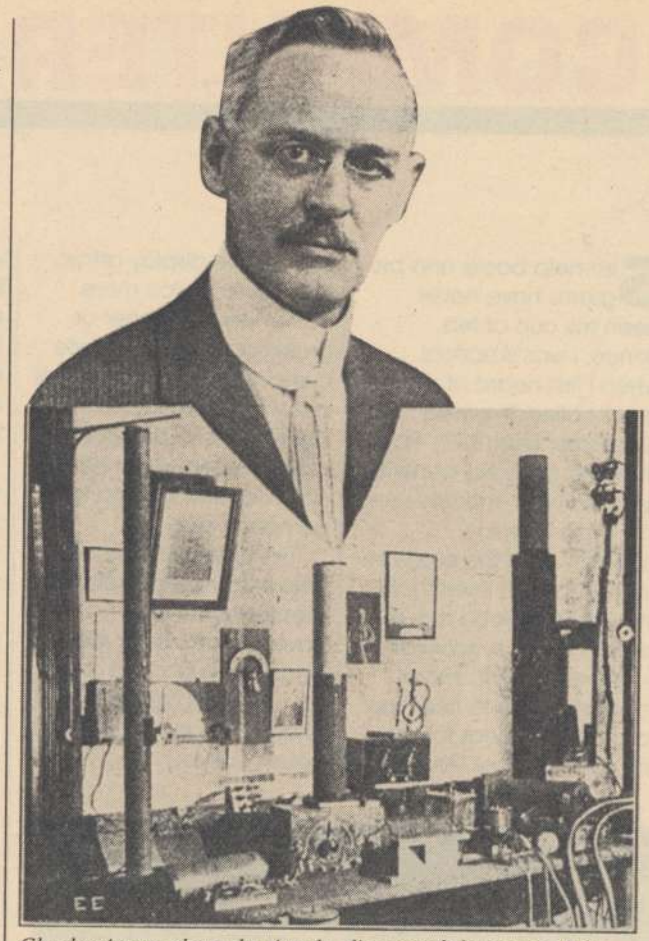
Back in the November issue, I ran an item ("The Kaiser's Clandestine Station") about a high-powered radio station built around 1915 in Tuckerton, NJ by German interests. According to information sent by reader Ron Oberholzer (North Cape May, NJ), the station was located in an isolated area, put together very quietly, if not exactly secretly, and probably used to direct U-boat activity. It was confiscated soon after our entry into World War I.

In concluding the discussion, I mentioned that I had read somewhere about a German station of the period that was closed down by our government after its "unneutrality" was exposed by a resourceful experimenter who deciphered its coded transmissions. I wondered if the Tuckerton station was

the one involved, and asked if someone could enlighten me.

As it happens, the person who wrote in—none other than Bart Lee of the California Historical Radio Society—was the source of the information I had remembered reading a few years ago. To jog my memory, Bart included a copy of his pamphlet *America's Wireless Spies*, which includes the story in question and a few others. Bart didn't mention whether this interesting pamphlet is still in print, but if you're interested in acquiring one, you might write him at Greenthumbs Press, 327 Filbert Steps, San Francisco, CA 94133.

In any case, quoting freely from Bart's write-up, here's how Charles Apgar, "America's First Radio Counterspy," exposed some German chicanery and closed a communications channel that was threatening Allied shipping.



Charles Apgar about the time he discovered the secret of the "Nauen buzz." The inset shows his listening post.

DECIPHERING THE "NAUEN BUZZ"

The radio station involved was not the Tuckerton installation, as I had surmised, but another German station: Telefunken-owned Radio WSL at Sayville, Long Island, New York. WSL regularly exchanged traffic with its sister station, Radio POZ, at Nauen, Germany (near Berlin).

Those who monitored transmissions between WSL and Nauen around 1915 were frequently treated to an odd listening experience. After the passing of routine traffic in ordinary Morse code, the stations often began sending an undecipherable chatter that became known as the "Nauen buzz."

The odd signal aroused government concern. The United States had not yet entered World War I, and it was our policy that all activities conducted on American soil be of a strictly neutral nature. Yet the "Nauen buzz" could easily be a coded transmission of sensitive information benefiting the German war effort.

Even though the U.S. Navy stationed observers at the station, however, nobody could prove that any of the activities carried out there were of an "unneutral" nature. Nobody, that is, until amateur-radio operator and electrical experimenter Charles Apgar entered the picture.

Apgar was a leading amateur-radio operator of the day, and had a special interest in audio recording. Using Edison Dictagraph cylinders, he had recorded the signals from WSL as early as 1913, and had even presented some of the cylinders to the station.

Some time in 1915, Apgar's Edison machine happened to slow down while he was playing back a recording of one of the "Nauen buzz" transmissions. As it did so, the undecipherable buzz changed to readable Morse code. The secret of the mysterious signal had been uncovered at last!

HOW THE GERMANS DID IT

Apgar turned over some 175 wax-cylinder recordings of the Sayville transmissions to the U.S. Secret Service. The nature of these transmissions is not now known, but apparently they provided telling evidence of war-related strategic communications. On July 6, 1915, the government seized WSL for violation of the U.S. Neutrality Act.

Somehow, Telefunken obtained advance notice of the seizure, and was able to remove critical equipment and evidence the night before. Thus, our ideas about how the "Nauen buzz" transmissions were created are based on supposition. However, we know that Sayville was equipped for automatic paper-tape keying, a technology that was routinely used in Europe to send Morse code at 100 wpm.

In a book published in 1915, Dr. Jonathan Zenneck, the station engineer at Sayville, reported that speeds up to 300 wpm had been achieved. That would certainly have been fast enough to create the "Nauen buzz." But how did the Germans receive this primitive "data burst" signalling and slow it down for replay?

It seems likely that the instrument used was a crude, early form of wire recorder known as the *Telegraphone*. Little known in the West, this machine was invented by Valdemar Poulsen of Denmark. It seems to have been an important means of confidential communications for the German armed forces, and was found even on certain submarines.

Such an instrument could easily be played back at a slower speed than that used for recording, making the signals intelligible in much the same manner as Apgar's Edison Dictagraph machine.

As Bart Lee points out in his pamphlet, one can easily imagine a submarine surfacing briefly, just long enough to record the "buzz," then quickly submerging for a leisurely

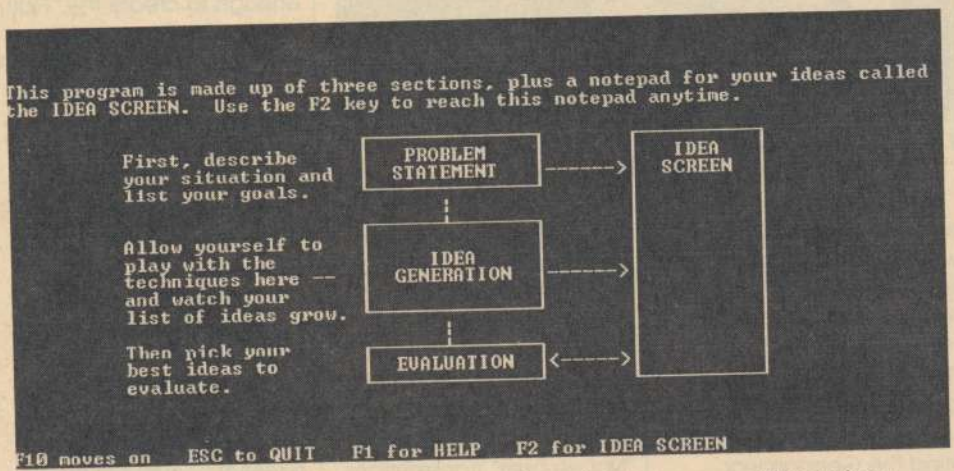
(Continued on page 84)

COMPUTER BITS

By Jeff Holtzman

Creative Thinking

Self-help books and programs have never been my cup of tea. Hence, I was skeptical when I first heard of a program called The Idea Generator Plus (TIGP). However, the potential benefits seemed high enough—and the hype level low enough—that the program seemed worth investigating. And I'm glad I did. TIGP doesn't claim to solve all your problems; its more modest goal is to help you to generate ideas for solving them yourself. And if you take the program even half-way seriously, it really can help.


This program is made up of three sections, plus a notepad for your ideas called the IDEA SCREEN. Use the F2 key to reach this notepad anytime.
First, describe your situation and list your goals.
PROBLEM STATEMENT
IDEA SCREEN
Allow yourself to play with the techniques here -- and watch your list of ideas grow.
IDEA GENERATION
Then pick your best ideas to evaluate.
EVALUATION
F10 moves on ESC to QUIT F1 for HELP F2 for IDEA SCREEN

The Idea Generator Plus helps you brainstorm creative solutions to your problems using a simple DOS interface. You can export results into any word processor, outline program, or personal-information manager.

The kinds of problems that it can help solve include those that you understand well enough to summarize succinctly. Here are several examples. A student needs to develop a list of possible topics for a research paper. A magazine editor needs to increase circulation and advertising. A retail-store owner needs to increase display attractiveness to entice more customers. A teacher or professor needs to create curriculum to grab students' attention. A business manager needs to develop more efficient methods of communicating among company divisions.

The Idea Generator can't help with vague, ill-defined problems. You've got to have a pretty clear idea of what you're working on. If you don't, though, a slight change of perspective may be all that you need to get started. Suppose, for example, that you feel bad about your job, but don't know why. Your goal in that case might be to understand why you feel bad, and develop a plan for improving things. Following through on the plan is, of course, up to you.

TIGP has four main sections: Problem Statement, Idea Generation, Evaluation, and Reports. The Problem Statement helps you to describe the situation that you wish to attack, specific goals that you wish to attain, their relative priorities, and the people involved (both helpers and hinderers).

Using a sort of interview technique, the Idea Generation section helps you to come up with new ways of understanding the problem by: 1. comparing it with similar situations; 2. creating metaphors for it; 3. viewing it from other perspectives; 4. focusing on goals one by one; 5. reversing goals; 6. focusing on the people involved; and 7. making the most of your ideas. You are encouraged to express whatever ideas come to you, without regard to their practicality or appropriateness. Even "bad" ideas may spark additional "good" ideas later on.

The third section involves evaluating your ideas according to goals, costs, benefits, and effects on people. The fourth section lets you print summary reports; you can also export a file as ASCII text or directly into several programs (GrandView, Agenda, etc.).

Using TIGP is simple: You can probably get by without reading the manual, although doing so is painless because it's short and to the point. The program also has a small online help module (non context-sensitive) that explains how to use the program; the program itself contains numerous hints on how to approach idea generation.

Each problem is stored in a separate file, and disk space is the only limiting

factor on the number of problem files. The program has no directory function, so an eight-character DOS file name has to spark your memory about the problem attacked in each file.

THE IDEA FACTORY

The heart of the program is section 2, Idea Generation. You can use any or all of the seven subsections to attack a given problem. Some methods may be more applicable to some problems than others, or you may find that your own mental processes function better in some areas than in others. In either case, that's fine; the point is to create new ways of understanding your problem. For example, as a writer, I find method 2 (developing metaphors) particularly valuable.

One interesting method is to reverse your goals, think about how to obtain the opposite, and then use those ideas to think about how to obtain the real (positive) goal. For example, suppose you were manager of a company and wanted to maximize employee satisfaction. The opposite goal would be to make employees miserable; ways of getting there would be to reduce wages, vacation, breaks, bonuses, and working conditions. (I don't know what it is about human nature that makes it easier to think about things in a negative way—witness the 1992 presidential race.) Now with the cards on the table, so to speak, it should be pretty easy to figure out how to make the employees happy.

Another interesting method is to view your situation from other perspectives. For example, method three allows you to hold a virtual or imaginary "board meeting" with anyone involved in the situation—and anyone else you'd care to invite—and then make suggestions from the perspective of each. For example, what would your siblings say, or your parents? How about someone you admire—a teacher, a public figure, a scientist, inventor, or writer from the past? It may sound silly, but making the effort can go a long way toward putting your problem into perspective.

After creating as many ideas as you can, you go to the evaluation section, which helps you group ideas, eliminate ones that are unfruitful, to estimate the effects on others, and to do a simple cost/benefit analysis. That's not to say that TIGP can substitute for a sympathetic friend, family member, or professional counselor. The program assumes you've got basic problem-solving capabilities, and a goal-oriented approach to solving those problems. Without them, the program probably won't do you much good.

The program normally lists for $195, but the company has arranged a special $79.95 offer for student readers of **Popular Electronics**. Contact Experience in Software, 2000 Hearst Avenue, Suite 202, Berkeley, CA 94709-9944; Tel. 800-678-7008, 510-644-0694. Tell 'em we sent you. ■

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CIRCUIT CIRCUS

By Charles D. Rakes

Using Stepper Motors

This month, we are going to explore an electronic component that is often overlooked or even avoided by the average electronics hobbyist. If you've never worked with stepper motors, and even if you have, this month's expedition just might spark an interest in using one of these electromechanical devices in a future project.

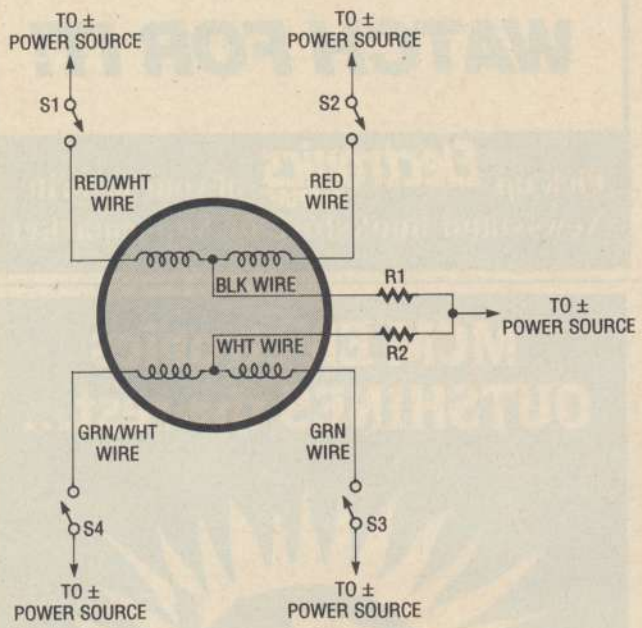

Fig. 1. This common 6-lead bifilar-wound stepper motor consists of two center-tapped windings. Note that the center tap of each winding is connected through a current-limiting resistor (R1 or R2) to a power source.

STEPPER MOTOR USES

Stepper motors play a prominent role in robotic technology. The manufacturing industry, with its robotic assembly lines, makes extensive used of these devices to move and precisely position parts for automated assembly and machining. Stepper motors are also used in computer-related equipment, such as in printers and disk drives.

Stepper motors, unlike your everyday garden variety of motor, are a breed of motors that are designed to rotate one step at a time—typically 1.8 degrees per step—in either direction. That means that the unit must undergo 200, 1.8-degree steps to complete one 360-degree rotation (200 × 1.8° = 360°).

Stepper motors, like other electronic components, are available in several varieties. Our discussion will center around the more common 6-lead bifilar wound configuration, illustrated in Fig. 1, which consists of two center-tapped windings. Note that the center tap of each winding is connected through a current-limiting resistor (R1 or R2) to a power source.

The motor is made to rotate in the desired direction by switching power to the motor windings on and off in the correct sequence. Before our motor (one salvaged from an old piece of machinery) could be placed into service, it was necessary to use an ohmmeter to determine and mark each coil and its center tap. To perform that operation, we used four SPST switches (numbered S1 through S4) connected to a power source (check voltage rating stated on the motor's nameplate before applying power to the motor) as shown in Fig. 1.

Then, as outlined in Table 1, the switches were activated (turned on) in various sequences; for example, step 1 indicates that switches S1 and S3 were turned on simultaneously to make the motor rotate one step at a time in a single direction. Try all four steps outlined in Table 1 and when the motor rotates smoothly in a single direction, you are ready to move on to the experimentation stage of our discussion. It may be necessary to move the motor windings to different switches until the armature rotates smoothly in one direction. Once you've achieved a smooth forward rotation, try the last four motor steps in Table 1,

TABLE 1—STEPPER MOTOR FULL STEP INPUT SEQUENCE

	STEP	SWITCHES			
		1	2	3	4
FORWARD	1	ON	OFF	ON	OFF
	2	ON	OFF	OFF	ON
	3	OFF	ON	OFF	ON
	4	OFF	ON	ON	OFF
REVERSE	4	OFF	ON	ON	OFF
	3	OFF	ON	OFF	ON
	2	ON	OFF	OFF	ON
	1	ON	OFF	ON	OFF

which should reverse the direction of rotation.

For what it's worth, the color coding of the motor windings shown in Fig. 1 corresponds to a popular stepper motor manufactured by Superior Electric (383 Middle St., Bristol, CT 060100).

BIPOLAR MOTOR-DRIVER CIRCUIT

A complete stepper-motor/driver circuit is shown in Fig. 2. In that circuit, two inverters (⅓ of a 4049 CMOS hex inverting buffer) are wired as a low-frequency squarewave oscillator. The operating frequency of the oscillator is determined by C1 and R11. The output of the oscillator at pin 6 of U1-b is applied to the clock input of U2 (a 4017 CMOS divide-by-10 counter) at pin 14. Note that pins 10 and 15 of U2 are tied together; that makes the U2 counter count from 0 to 3 and repeat as long as clock pulses are present at pin 14.

The four outputs of U2 are each simultaneously fed to two of the four driver-transistor circuits through eight steering diodes, D1–D8. Each driver circuit is comprised of two transistors; one of which (a 2N2222A general-purpose bipolar unit) is used a current amplifier, and the other (a 2N3055 power transistor) acts essentially as a switch. The current amplifier is used to provide sufficient base-drive current to the power transistor to ensure full saturation at turn on.

When the 0 count output of U2 at pin 3 goes high, a positive-bias pulse is applied to the base of Q1 and Q3 through steering diodes D2 and D3 respectively, causing them to momentarily turn on. That causes a positive bias to be applied to both Q5 and Q7, turning them on momentarily. That in turn applies power to their connected motor windings, causing the motor's armature to move one step and lock in place until the next pulse arrives.

The oscillator frequency can be adjusted via R11 to increase or decrease the motor's rotational speed. Of course, there is a limit to how fast each type of stepper motor can operate; if the motor is pushed beyond its rated speed, it will either sit in one position and chatter or run erratically. Setting the oscillator frequency to 3.3 Hz will cause the motor to rotate at 1 rpm; adjusting the oscillator frequency to

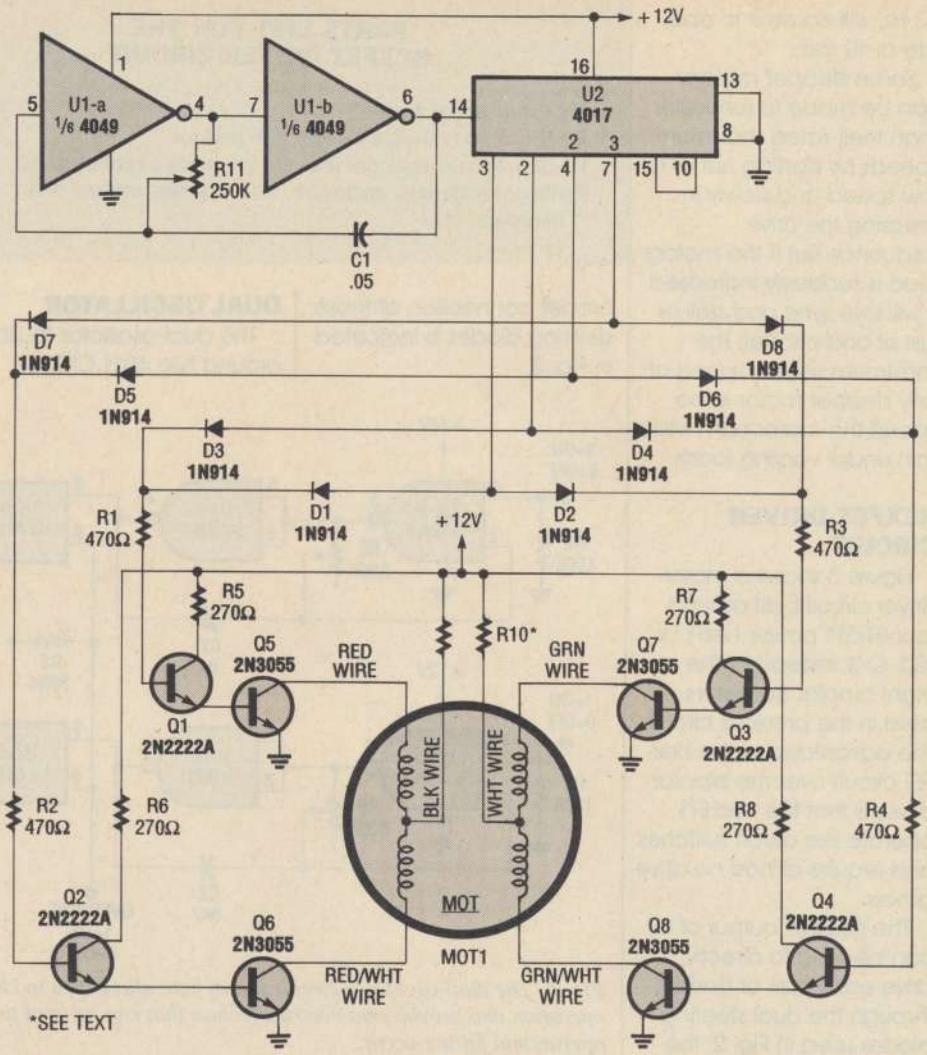

Fig. 2. In the bipolar stepper-motor/driver circuit the individual drivers are comprised of two transistors; one of which (a 2N2222A general-purpose bipolar unit) is used as a current amplifier, and the other (a 2N3055 power transistor) acts essentially as a switch.

PARTS LIST FOR THE BIPOLAR MOTOR-DRIVER CIRCUIT

SEMICONDUCTORS

U1—4049 CMOS hex inverting-buffer, integrated circuit
U2—4017 CMOS decade counter/divider, integrated circuit
Q1–Q4—2N2222A general-purpose NPN silicon transistor
Q5–Q8—2N3055 NPN silicon power transistor
D1–D8—1N914 general-purpose silicon diode

RESISTORS

(All fixed resistors are ½-watt, 5% units, except where otherwise noted.)
R1–R4—470-ohm ½-watt resistor
R5–R8—270-ohm, ½-watt resistor
R9, R10—Power resistors selected for motor's current rating

ADDITIONAL PARTS AND MATERIALS

C1—0.05-μF, ceramic-disc capacitor
MOT1—12-volt stepper motor
Perfboard materials, enclosure, IC sockets, 12-volt power source, wire, solder, hardware, etc.

33 Hz, will cause it to operate at 10 rpm.

Some stepper motors, can be made to run faster than their rated maximum speeds by starting out at a low speed and slowly increasing the drive frequency. But if the motor's load is suddenly increased it will lose sync and stall or just sit and chatter. The maximum usable speed of any stepper motor is the speed the motor can maintain under varying loads.

HEXFET DRIVER CIRCUIT

Figure 3 shows a motor-driver circuit built around four IFR511 power hexFET's (Q1–Q4), instead of the eight bipolar transistors used in the previous circuit. The advantage of the hexFET circuit over the bipolar driver is that the hexFET's operate like on/off switches and require almost no drive power.

The positive output of U2 can be used to directly drive each pair of hexFET's through the dual steering diodes used in Fig. 2; the proper connection of those steering diodes is indicated in Fig. 3.

PARTS LIST FOR THE HEXFET DRIVER CIRCUIT

Q1–Q4—IRF511 hexFET
R1–R4—100,000-ohm ¼-watt, 5% resistor
R5, R6—Power resistors selected for motor's current rating
Perfboard materials, enclosure, 12-volt power source, wire, hardware, etc.

DUAL OSCILLATOR

The dual-oscillator (built around two 4011 CMOS NAND-gate integrated circuits) shown in Fig. 4 can be used in place of the single, inverter-based oscillator used in Fig. 2. The dual-oscillator circuit allows you to choose either high- or low-speed operation and provides an override feature that can be used as a safety control to shut the system down should an operational failure occur.

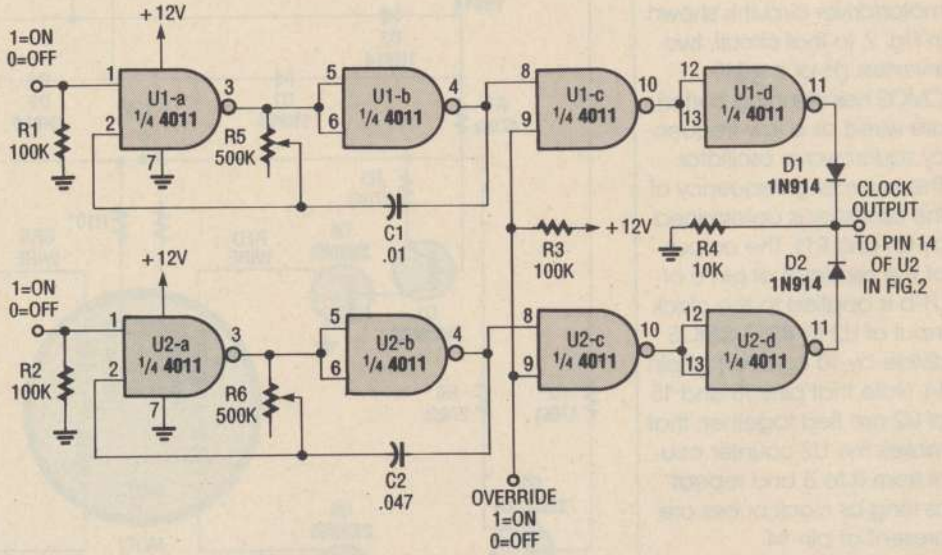

Fig. 4. The dual-oscillator circuit shown here allows you to choose either a high- or low-speed operation and provides an override feature that can be used to shut the system down should an operational failure occur.

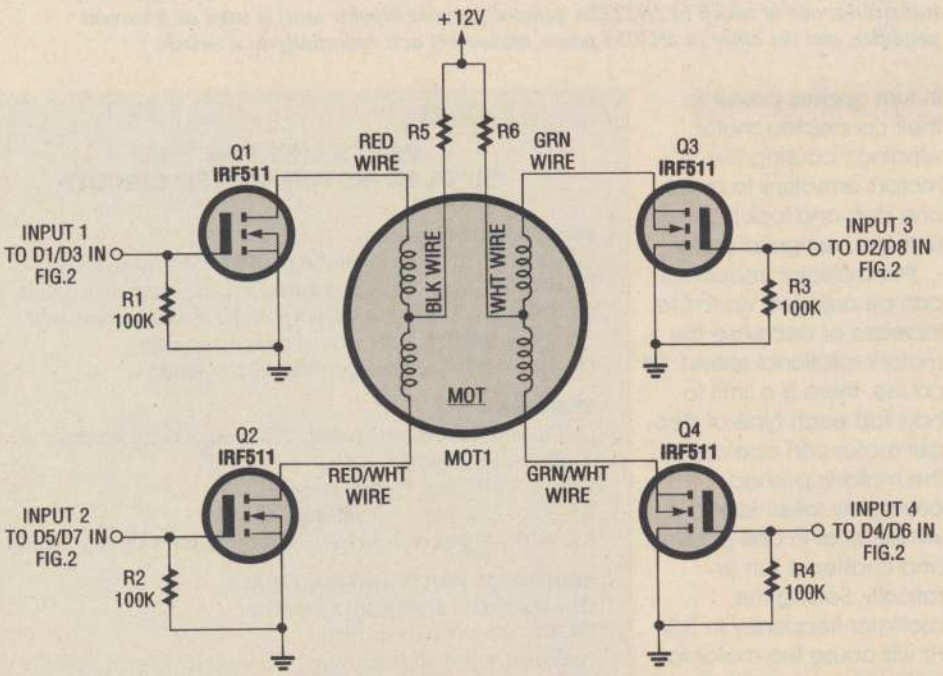

Fig. 3. This motor-driver circuit replaces the eight bipolar transistors of the previous circuit with four IFR511 power hexFET's (Q1–Q4).

In the high-speed oscillator, U1-a and U1-b are configured as a square-wave oscillator; pin 1 of U1-a controls the oscillator's on/off function, with a high input turning the oscillator on and a low input stopping it. The operating frequency of the high-speed oscillator is determined by C1 and R5 (which can be varied to adjust the oscillator's frequency of operation).

The low-speed oscillator (built around U2) operates in a like manner with pin 1 of U2-a controlling the on/off function of that oscillator, and R6 providing the frequency-adjust function.

The output of the high-

(Continued on page 92)

THINK TANK

By John J. Yacono

Binary and Equipment

Hello and welcome to another edition of *Think Tank*. This month I'm going to continue the tutorial on IC's. If you read last month's column, you know that we've already covered some common IC packages. This month, we'll discuss how binary numbers are represented by voltages. I will also continue to present some test equipment circuits sent in by clever readers.

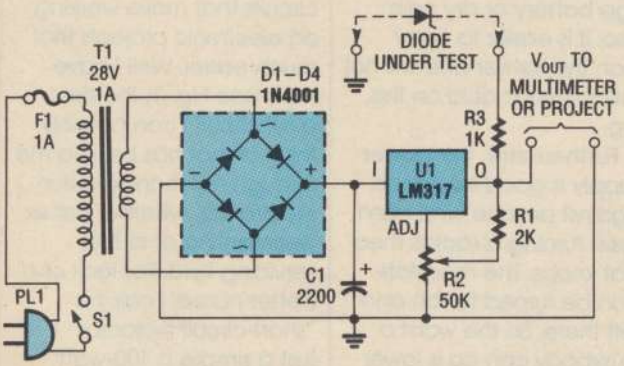

Fig. 1. This versatile circuit can be used to test Zener diodes or act as a stand-alone power supply. Note that it requires a voltmeter to work as a Zener tester.

By the way, the responses to my query last month (do you want more, less, or the same amount of computer coverage in this magazine) have been coming in. If you would like to express your opinion, please send it in; and thanks to those who've already contributed.

To the gentlemen who feared that I posed the question because I might be out of non-computer-related ideas: **Don't you believe it!** My stack of ideas for various projects and topics grows on an almost daily basis (much faster than I can build them or write about them) and has greatly accelerated in growth since I started writing this column.

In fact, I asked reader's about what they would like to see because I have too many ideas and want to weed out the ones of least interest. As long as this column has a following, I'll keep pumping out the ideas. I promise.

BINARY NUMBERS

Basically speaking, whether a logic circuit is used to turn on a light bulb or correct a satellite orbit, it performs its job by doing math. Not the kind of math that we are used to—based on digits from one to ten—but Boolean algebra, more commonly called logic, which is performed using only two numerals: zero and one.

Since there are only two numbers in this branch of mathematics, the digits form what is called the binary (two-numeral) number system. If you are unfamiliar with binary, you might be wondering how to represent the number three in binary.

To help answer that question, consider what happens when we count in our number system (the decimal system). Once we count from zero to nine, we run out of digits, so we place a zero in the ones position and a one to the left of it (in the tens position) to indicate that we have already counted from zero to nine once. That gives us the number ten (10).

If we count in binary, we start with zero (0), proceed to 1, and since we've run out of digits, the next number (two) is represented by 10 (read "one, zero") in binary, three is written 11, and so on.

VOLTAGE LEVELS

Of course, logic circuits don't have the ability to conceptualize numbers, they simply respond to voltages. So in a logic circuit, the binary numbers (one and zero) are represented by voltage levels. In positive-logic circuits, a voltage close to 0 volts represents a logical zero (or "logic low"), while a voltage reasonably close to the power-supply voltage is defined as a logical 1 (or "logic high").

Negative-logic circuits (which are less common than positive-logic) work in the opposite manner; a logical one is represented by a low voltage that's close to zero, while a logical zero is represented by a high voltage. Since negative-logic circuits aren't too numerous, I'll stick to discussing positive-logic circuits. However, keep in mind that all the technical attributes (power-supply requirements, fabrication techniques, architecture, etc.) of positive-logic chips are the same for negative-logic chips. The only distinction between the two is their definition of what is a one and what is a zero.

Next month, we'll discuss the exact values of voltage used by common circuits to represent binary ones and zeros. For right now, though, let's get to our letters.

ZENER TESTER

The following is a supply that I built for testing Zener diodes (see Fig. 1). It also

doubles as a 1.5- to 25-volt variable-voltage power supply. The only critical parts are the voltage regulator and the 1k current-limiting resistor that goes to the cathode lead. Without that resistor, the Zener (and my finger) would be burned. I use my analog multimeter to read out the Zener voltage. So, do I get a Fipps?

—Jerry Clark, Galveston, TX

Very nice. I like the fact it can play a dual role (as a Zener tester and a power supply). A similar supply could be built by substituting a 240-ohm resistor for R1, and a 5k potentiometer for R2. However, finding 5k potentiometers might take some scrounging.

By the way, we don't have any more Fipps books, so I'll be sending you a Think Tank II *book instead. I hope that will be okay.*

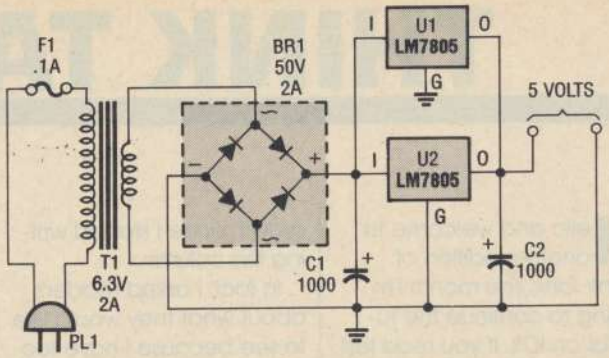

Fig. 2. This DC supply is great for operating battery-powered antique radios, as it is designed to prevent harming the tube filaments.

ANTIQUE-RADIO SUPPLY

Those who own antique radios that use 01-A tubes may occasionally wish to exhibit them in operation at shows, etc. Production of 01-A's ceased in 1940, so they are all quite old and hence fragile, so the shock of having the full 6.3 volts of a storage battery applied to them may destroy their filaments.

With used 01-A's going at $12.50, the cost of the power supply shown in Fig. 2 is a good investment. It is cheaper than either a storage battery or dry cells. Also, it is easier to carry than the former and will not spill sulphuric acid on the rug.

Furthermore, the power supply is good insurance against anyone who can't resist turning a radio's rheostat knobs. The rheostats can be turned full on and left there. So the worst a busybody can do is lower the filament voltage.

Some regenerative detectors use the filament rheostat to control regeneration. The rheostat controlling the detector-tube filament will function normally using this supply. Receivers with up to 8 tubes, including any mix of 00-A, 01-A, 112A, or 71-A tubes, can be powered from the supply as these all require 5 volts DC at 0.25 amps. Look out for tubes with the same numbers but no A. They draw 1 amp each.

The LM7805's can be physically piggy-backed for convenience in wiring. Just mount one onto the other and solder their leads together. If one's clutch pile includes some surplus computer supplies, very likely most or all of the parts can be salvaged, reducing the total cost.

—Billy R. Pogue, Lake Hauasu City, AL

I'm sure a lot of antique-radio buffs will like your circuit. I was a little surprised that the regulators don't enter a tug-of-war with each other. That can happen if their output voltages are slightly different, but you sound like you've used the circuit enough to know what you're talking about. I'll probably build this circuit to test its characteristics myself.

AC-SHORT DETECTOR

A while back, you presented some very simple circuits that make working on electronic projects that much easier. Well I have here (see Fig. 3) the simplest circuit I can possibly think of that has helped me through my many years in electronics, whether just experimenting or in the servicing field. For lack of a better name, I call it a "short-circuit indicator." It is just a simple a 100-watt bulb connected in series with the power line and an AC outlet.

I use this circuit on my test bench. Whenever I'm in doubt as to the condition of an AC device under test (DUT), instead of plugging the device directly into the house AC lines, I plug it into my short-circuit indicator. If the light bulb lights very brightly, I know that there is a short circuit in the DUT. If the light bulb lights dimly, then I know that the DUT is not short circuited and can be safely plugged in.

This circuit has saved me from blowing fuses late at night when I do most of my work. I'm sure that your avid readers might think of some other applications for this simple gadget.

—John A. Alvarez, Richmond Hill, NY

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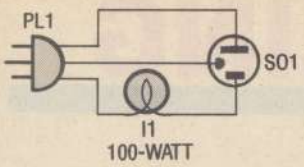

Fig. 3. Do you deal with old equipment in unknown condition? If so, this little circuit could keep you from causing further harm to already shorted devices.

companion for the power supply that we just discussed. Antique-radio enthusiasts can use the circuit to test for bad power-transformer primaries without damaging their latest acquisitions. However, anyone interested in repair work could use one of these gadgets. Thanks, your book is on the way.

Now let's switch gears. Instead of continuing with another piece of test gear, I'd like to present a letter that will help a former contributor to this column.

INTERCOM AGAIN

There may be several reasons why George R. Cote of Pittsfield, MA (August 1992 *Think Tank*) is having trouble with the June 1991 telephone power supply (see Fig. 4). One is that most telephones need at least 20 mA of loop current to operate, and many electronic phones require even more current. The fact that he is only drawing 7.96 mA with one phone off-hook is why he can't hear anything.

For a 12-volt DC supply, an output resistance of 1k (total value of R1 and R2) is probably too high. Battery-powered circuits need to present a reactive load, so that they provide some current reduction while presenting a high impedance at audio frequencies. It looks like the designer of this circuit tried to get around using inductors on each side of line by just

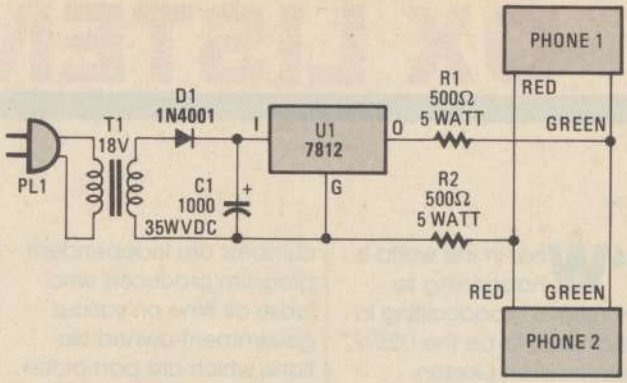

Fig. 4. One reason why George is having trouble with the telephone power supply is that most telephones need a loop current of at least 20 mA to operate.

going to a high resistor value, so that the audio would not sink into the power supply.

That may work on short line lengths to the phones at a standard telco voltage of 48 volts DC, but seems to have gotten George into trouble at 12 volts DC. Maybe using inductive wirewound resistors at 50 or 100 ohms would work. Just make sure that the power rating of the resistors can handle the current involved. Figure on an off-hook resistance of about 200 to 400 ohms for most phones.

Another problem can crop up with some electronic phones, and that is that they may be designed to work only at 48 volt DC, no matter how high the current is at 12 volts. Many inexpensive electronic phones have a Zener in series with the line; a monolithic telephone IC is then powered from the Zener-regulated voltage. If 12 volts is not enough to cause the Zener to conduct, the phone can't "turn on" and produce a proper off-hook condition.

A better solution for George may be to get four 12-volt lantern batteries wired in series to produce 48 volts DC, and wind his own inductors. The higher the series resistance presented by the inductors, the longer the batteries will last, as long as they deliver enough current to run the phones. To be on the safe side, 30 or 40 mA is a good minimum value.

If George wants to have 48 volts DC and standard telco ringing, the 46220 Telephone Hotline from Proctor and Associates of Redmond, WA may be the answer. The device provides connections for two phones; when one of the phones goes off-hook, the 46220 sends standard telco ringing voltage at 105 volts AC, 20 Hz to the other phone. You can contact Proctor at 206-881-7000; their fax number is 206-885-3282.

—Tad Cook, Seattle, WA

Thank you very much for your letter, I'm sure the information you have provided will really help George. You really know your phone technology.

That's all the room we have for this month. Don't forget, if any of you have interesting circuits or helpful advice then write to *Think Tank*, **Popular Electronics**, 500-B Bi-County Blvd., Farmingdale, NY 11735. Your effort will be rewarded with a copy of *Think Tank II* or another selection from our library. ■

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CIRCLE 9 ON FREE INFORMATION CARD

DX LISTENING

By Don Jensen

SW Since The USSR Breakup

"What in the world is happening to shortwave broadcasting in what used to be the USSR?," queries Brian Garson, Raleigh, NC, in a recent letter. "When I listen in on some of the DX programs, like Radio Nederlands' Media Network, they talk about all sorts of independent shortwave stations in Russia. I'm surely confused."

Brian's not the only one feeling a bit perplexed. The shortwave situation in the former USSR has been very confusing since that country's breakup. There seem to be dozens of new Russian stations, most of which are reported to be broadcasting in the Russian language, but some do have limited English programming. Actually, according to the most reliable information available, there are very few genuinely independent Russian SW stations, if we define stations in the generally accepted sense.

SWL fans of the DX Partyline show have often heard veteran HCJB producer John Beck filling in during regular host Rich McVicar's Winter-long absence from the air.

What we have in growing numbers are independent program producers who lease air time on various government-owned stations, which are part of the vast transmitter network left over from the "pre-democracy" days of Soviet international broadcasting. Most of those new program services are the work of present and former employees of the now defunct Gostelradio (the former Soviet broadcasting agency). They are intended as commercial operations, but it's unclear just how much advertising they have been able to attract thus far.

The largest of those "independent" broadcasters, supposedly, is *Radio Ala*, which began broadcasting in October 1991. Its programming, in the Russian language, consists mostly of music, with newscasts on the quarter hour. Ala, says N. Dyomina, the station's letters editor, means "*wings*, from the Latin." The program has its own news-gathering and writing staff, and claims to have as many as 75-million listeners in Russia.

It broadcasts its program from transmitters, leased from the Russian government, at Moscow, St. Petersburg (formerly Leningrad), Ekaterinburg, and Kalingrad at various times and at up to about 12 hours a day or more. Some frequencies to try are: 7,370, 7,400, 11,685, 11,965, 12,030, and 15,255 kHz. Radio Ala's address is P.O. Box 159, 125047 Moscow, Russia.

MAILBOX TIME

Ah, the mail just keeps coming! And that's wonderful! I'm always glad to get feedback from readers. If you would like to get on board too, drop me a line. Tell me which are your favorite SW stations? Pass along your listening tips. I'm looking for your comments on the world-band broadcasting scene. Do you have questions about the SWL hobby? While I'm unable to personally reply to your queries, I'll answer the most interesting letters here each month. Send your letters (photos of you and your SWL'ing equipment, too) to me, in care of **Popular Electronics**, 500-B Bi-County Blvd., Farmingdale, NY 11735.

"Myers is in, Meyer's out," writes Tom Marciniak, Coral Gables, FL, who has been a faithful listener to Tom Meyer's popular Happy Station program Sundays on *Radio Nederland*. "Tom Meyer had been hosting the Happy Station program for 22 years when he announced he was leaving to take up writing and dramatic interests. He was replaced by Pete Myers, who, himself, has been a longtime RN announcer."

Radio Nederland's Happy Station program dates back to 1928, when the Dutch first went on shortwave with pioneer station, PCJ. Eddie Startz hosted the multi-lingual show until 1970 (with an enforced interruption during the Nazi occupation of Holland during WW2). Meyer then took over for more than two decades. Myers becomes the Happy Station's third host in 65 years!

STUCK ON STICKERS

Mary Ann Smith, of Meridian, MS, writes, offering this tip for other SWL's who like to collect those "little extras," that some stations send with their replies to listeners who write them about their reception.

"*Radio New Zealand International* sent me a really nice station sticker," she writes. "It came along with their current schedule and a verification card. If anybody wants to send RNZI a reception report, their address is Post Office Box 2092, Wellington, New Zealand."

Thanks, Mary Ann! And for readers who may be looking to log New Zealand, try 9,700 kHz during the early morning hours, between 0700 and 1130 UTC.

Speaking of UTC, I've received a couple of letters concerning my question (a few issues back) about the use of the letter Z or, phonetically, Zulu, to signify Universal Coordinated Time (UTC) or its predecessor, Greenwich Mean Time (GMT). For beginning listeners who still may be a bit confused about the use of UTC by most SW stations, it is a time standard equal to EST + 5 hours, CST + 6, MST + 7 or PST + 8.

Henry Schanding (ham-radio operator, W3RRF), Elizabeth City, NC, says the Z stands for Zero degrees Longitude, the Greenwich Meridian. Another radio amateur, Norman Wehrli (W5JKPC), Athens, TX, confirms my supposition, conveyed in last October's column, that Z or Zulu time references date to World War II military usage.

"The world is divided into 26 time zones," says Norman, "and each is designated by a letter from the standard phonetics. The Z or Zulu time zone covers the area of Greenwich, England, where GMT/UTC is based. "The United States time zones are designated, under the same system, with R (Romeo) for EST, S (Sierra) for CST; T (Tango) for MST, and U (Uniform) for PST." Thanks Norman.

*Credits: Brian Alexander, PA; Jim Clar, NY; Richard D'Angelo, PA; Dan Ferguson, VA; William Flynn, OR; Harold Levison, PA; North American SW Association, 45 Wildflower Road, Levettown, PA 19057.

MORE MONITORING

"I've always been fascinated by the idea that some shortwave listeners get paid for doing, more or less, what the rest of us do for fun," writes Fran Martieri, Terre Haute, IN. "I knew that a number of countries and their shortwave services employ professional monitors to listen in on what the other guys are broadcasting. There are, of course, agencies such as the U.S. government's Foreign Broadcast Information Service, the BBC's Monitoring Service and the professional monitors employed by Germany's Deutsche Welle and Canada's CBC.

"But," Fran continues, "I didn't know that *Radio Moscow* had a similar SW-monitoring service until I heard about it on a Radio Nederland Media Network program. It seems that the USSR's Communist Party Central Committee established its monitoring service back in 1964. Since it was taken over by the Russian Federation, after the break-up of the USSR, it has gone commercial, providing a daily digest of its monitoring operation of 27 international stations to clients such as financial institutions, banks, and businesses. It supposedly has a staff of about 50, who monitor some 50 hours of broadcasts per day."

DOWN THE DIAL

Looking for some interesting stations to tune? Try a few of these.

AUSTRALIA—21,740 kHz. *Radio Australia* broadcasts have been noted here at 0120 UTC, with news, commentary, and musical programming.

BRAZIL—15,445 kHz. *Radio Nacional da Brasilia* broadcasts in English from 1155 to 1320 UTC, with its "Panorama" program. The station announces its address and promises to reply to all mail.

KAZAKHSTAN—17,730 kHz. *Radio Alma Ata* has English-language programming that can be heard here at around 1830 to 1900 UTC.

UKRAINE—11,790 kHz. *R. Ukraine Internationa* has been heard in English, broadcasting to U.S. and Canadian listeners at 0000 UTC. It also uses 12,040 and 15,580 kHz, according to announcements.

UNITED STATES—9,495 kHz. *WHRI*, World Harvest Radio, Noblesville, IN, carries extensive Spanish programming, during the morning and evening, which the Cuban American National Foundation aims at audiences in Cuba. But, in a "reprise" of the Cold-War radio era, some of the programs during the 0000 to 0500 UTC period have been jammed by Cuba. Newcomers to SWL'ing may wish to tune-in to that station simply to hear what "white noise" jamming sounds like. Jamming, which not too long ago blocked many SW frequencies, is rarely encountered these days. How times have changed! ■

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CIRCLE 5 ON FREE INFORMATION CARD

Direct Conversion Receivers

By Joseph J. Carr, K4IPV

The direct-conversion receiver (DCR) is one of the simplest forms of radio receiver. Like the superheterodyne receiver, it uses a local oscillator (LO) to down-convert the RF signal. But there is a difference; in the superhet receiver, the LO output and the received RF are of different frequencies. The two signals are combined to produce a sum or difference frequency, which is then processed as an intermediate frequency (IF).

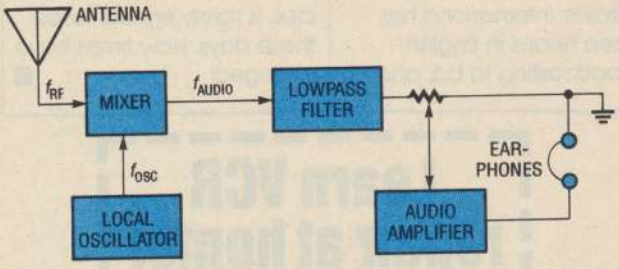

Fig. 1. The composition of a direct conversion receiver (DCR) can be easily illustrated through this block diagram, consisting of a local oscillator, a mixer (a double-balanced type is preferred), followed by a low-pass filter, and an audio amplifier.

In the DCR, the LO frequency is on or close to the RF. Thus, when an SSB signal is received, and the LO is adjusted to within a couple kilohertz of the RF frequency, the SSB signal is demodulated directly to audio. Similarly with a CW signal, setting the LO to within, say, 800 Hz of the RF signal produces an 800-Hz beat-note CW signal in the output.

One of the nice things about the SSB-type circuit is that both lower sideband (LSB) and upper sideband (USB) can be accommodated by placing the LO either immediately above or immediately below the RF signal. Neat, huh?

DIRECT CONVERSION RECEIVERS

Figure 1 shows a block diagram for a direct conversion receiver. The mixer (preferably of the double-balanced variety) can be passive or active. The mixer is followed by a low-pass filter that has an upper −3-dB frequency of 3000 Hz. The filter reduces the noise level by passing only those frequencies that are necessary, while also removing any residual RF or LO signal that manages to "sneak past" the conversion process.

In a DCR that uses an active mixer, the audio amplifier provides most of the gain in the circuit. On the other hand, if a passive mixer is used, the audio amplifier provides all of the gain in the circuit! In such unit, the amplifiers tend to have gains on the order of 80 to 120 dB in order to obtain good listening levels.

Notice that the circuit does not contain an RF amplifier, although some DCR designs do. In general, circuits designed for use below 14 MHz do not require an RF amplifier. Indeed, if an RF amplifier is used in the design, it may be overdriven. Examine signals on the 40-meter band at about 2100 hours each evening to get an idea of what I mean. The dynamic range of those signals can extend from "whispers of hot air to bone crushing blowtorches" (whether originating from local ham operators or international broadcasters).

There are several approaches to making DCR receivers for the ham bands. So this month and next month, we will take a look at two of the most popular forms of DCR circuit. The one that we'll discuss this month uses an active mixer and is built around the popular NE602/LM386 circuit combination. We'll follow up next month with a look at circuits based on a passive, double-balanced mixer.

The NE602 is an integrated circuit made by Signetics and sold by Digi-Key (P.O. Box 677, Thief River Falls, MN, 56701-0677; Tel. 800-344-4539). It has two sections; a multi-transistor Wilson Transconductance Cell connected as a double-balanced modulator (DBM), and a single-transistor local-oscillator circuit. The emitter and base connections of the local oscillator are brought out to pins 6 and 7 of the unit. The LO can operate at frequencies of up to 200 MHz, while the DBM can perform at frequencies ranging as high as 500 MHz.

The other chip, the LM386, is a low-voltage audio-power amplifier, which is capable of putting out about 500 mW of audio power. It contains the audio preamplifiers and power amplifiers needed to make the complete audio-amplifier section of a radio receiver.

A LOOK AT THE CIRCUIT

Figure 2 shows a schematic diagram for a direct-conversion receiver built around the NE602/LM386 combination, which is based on a design by John Dillon (WA3RNC). A parts kit

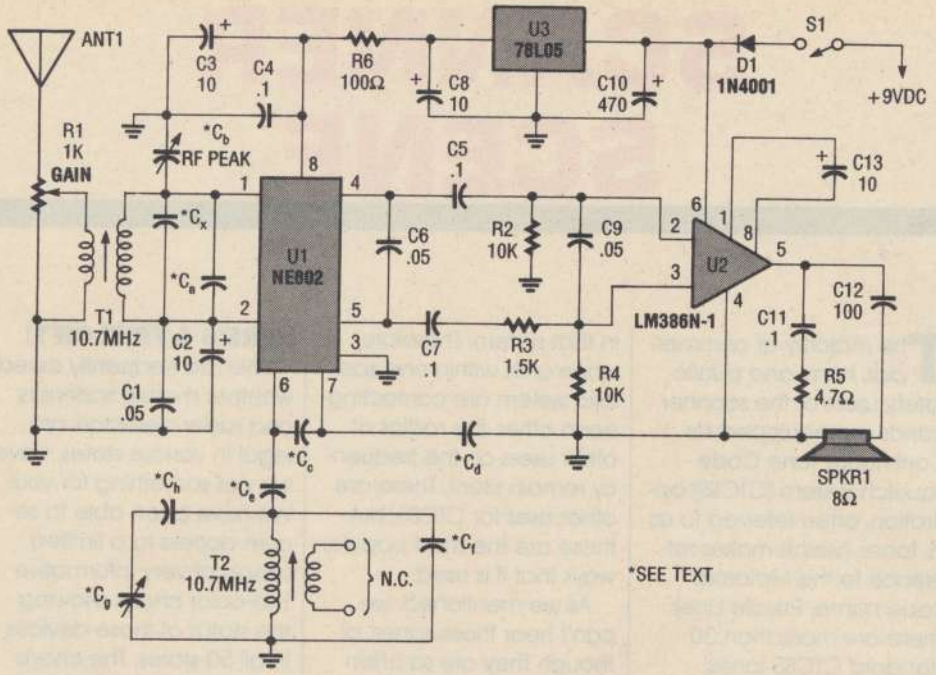

Fig. 2. This direct-conversion receiver, built around the NE602/LM386 combination and schematically represented here, is based on a design by John Dillon (WA3RNC).

for the actual Dillon version, which covers 75/80 and 40 meters (depending on the capacitors selected) is available from Penntek Electronics (14 Peace Drive, Lewistown, PA 17044). The parts kit, which includes a printed-circuit board and all the parts needed except the loudspeaker or earphones, and the variable capacitors, sells for $19.95.

Although DCR's are said to be prone to hum and instability, I found no sign of either problem when I configured the receiver to the 80-meter band. Actually, it performed quite well. I then built another one on perfboard, configured (as shown in Fig. 2) for the 40-meter band, for educational purposes.

For the input transformer and local-oscillator coils, I used 10.7-MHz IF transformers, like those available from Mouser Electronics (POB 699, Mansfield, TX 76063; Tel. 800-346-6873) as part No. 421F123. In the case of the input coil, the internal capacitor (C_x) is used to help resonate the coil. Because the coil was originally tuned to 10.7 MHz, additional capacitance was needed to resonate the coil to lower bands.

In the Dillon design, capacitor C_a is 330 pF, while C_b is a dual-section capacitor of 59 pF and 140 pF with both sections connected in parallel. However, while toying with my experimental version, I discovered that replacing C_b with a 440-pF variable capacitor, and not using C_a at all, allowed me to tune the coil down into the bands of interest. I was then able to adjust T1's tuning slug to allow the 440-pF capacitor to tune both 80/75 meters and 40 meters. The local-oscillator components, as shown, are connected to pins 6 and 7. The inductor (T2) is another 10.7-MHz transformer, but the secondary is not used. Table 1 lists the capacitor values (in picofarads) required for the 80/75- and 40-meter bands; all of the capacitors should be silvered mica, NPO ceramic, or polystyrene units.

Those values will also work in adjacent bands. For example, if you want to use the receiver in the 8-MHz marine-CW band to listen to ships, use the 40-meter values and retune the coils.

The parts kit is of high quality. The only criticism I have of the kit is the lack of instructions. John designed it for an ARRL publication about five years ago, and has been selling it ever since. However, as time goes on, fewer people have the original article. Ask him for a copy of the article when you order. ■

TABLE 1—CAPACITOR SELECTION

Band	Capacitor Values (picofarads)					
(meters)	Cc	Cd	Ce	Cf	Cg	Ch
75/80	1000	1000	470	120	365	270
40	330	330	120	150	365	68

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SCANNER SCENE

By Marc Saxon

Scanning the Final Frontier

The majority of commercial, ham, and public-safety users of the scanner bands are equipped for Continuous Tone Code Squelch System (CTCSS) operation, often referred to as PL tones (which makes reference to the Motorola trade name, Private Line). There are more than 30 standard CTCSS tones, each of which is sub-audible. CTCSS-equipped stations in a given system all use the identical tone, and it is continuously sent out by each station while it is transmitting.

You can use the Tone/Code Finder to locate and decode all CTCSS tones.

Why is that done? One reason is to permit only certain stations to access a repeater that will not key up except when it detects a signal on its input frequency that has the correct CTCSS tone. Another reason is to allow several different users to share the same frequency without causing too much disturbance to one another. Each user on the frequency has all of their units set up with a particular CTCSS tone, and it takes that particular tone to open the squelch of every radio in that system. Therefore, when units within one specific system are contacting each other, the radios of other users on the frequency remain silent. There are other uses for CTCSS, but those are the most popular ways that it is used.

As we mentioned, we can't hear those tones, although they are so often present and they are very distinguishing characteristics of the signals that we regularly monitor from police, ham, business, and many other types of stations. Other than ham stations, most VHF/UHF users aren't overly anxious for outsiders to learn which CTCSS tones they use.

An interesting scanner accessory is available, however, that finds and decodes all CTCSS tones, and then displays them via large LED's. You can park your scanner on one frequency used by several systems and sort them all out by getting an instant reading of the CTCSS tones employed by each station that you're monitoring. Some systems use digital codes instead of CTCSS tones, and the accessory can also read those. It connects inside most late-model Bearcat and Realistic desktop scanners.

There are several versions of the unit, which is known as the Tone/Code Finder, available from Automated Industrial Electronics Corporation, 141 Granite Street, Batesburg, SC 29006, Tel: 803-532-9256.

HERE'S A FREE GIFT!

We are frequently asked whether mobile scanners and radar detectors are legal in various states. Have we got something for you! We have been able to secure access to a limited supply of very informative two-color charts showing the status of those devices in all 50 states. The charts also indicate special high-tech speed-enforcement techniques, such as places where Stalker (wide Ka-band) radar is used, as well as pinpointing where photo radar, laser guns, aircraft speed enforcement, and VASCAR are active.

While our supply lasts, we will be able to send one of these excellent charts absolutely *free* to any reader who requests one. To get yours, send us a *long*, self-addressed, stamped (29-cents) envelope. Address your request to *Scanner Scene* at the address shown at the end of this column.

UPDATED & REVISED

One of the more popular scanner and shortwave directories has long been *Tune in on Telephone Calls*. The 160-page book has become the official handbook for those who are fascinated by tuning-in on phone calls from homes, offices, cars, aircraft, boats, and even trains.

There is now a fine, new, updated and revised edition, containing hundreds of new and changed frequencies. It includes such

Tune In On Telephone Calls
Scanner & Shortwave Frequency Directory
By Tom Kneitel, K2AES
Revised & Updated!
100's of New Freqs.

The revised edition of this scanner- and shortwave-frequency directory includes loads of new and updated information.

information as the band for 900-MHz cordless phones, plus new frequencies for the 46/49-MHz cordless-phone band. Hundreds of HF high-seas telephone-call channels have been changed. New frequency information for phone calls from offshore oil-drilling rigs is provided, as well as updated information for the radio service created just to bring phone calls to rural, remote, and wilderness areas. New radio-paging frequency information is provided, too. Loads of new information in the book is intended to increase your monitoring enjoyment.

The revised *Tune in on Telephone Calls* is available from many scanner shops. Or you can order it by mail for $12.95 (plus $3.50 shipping) from CRB Research Books, P.O. Box 56, Commack, NY 11725. Residents of New York must add $1.40 sales tax. Visa and MasterCard orders (USA only) are accepted by mail and by phone (Mondays, Tuesdays, Thursdays, and Fridays, 10 AM to 2 PM Eastern Standard Time only) at 516-543-9169.

SPACED OUT ON SCANNING

Scanning signals from the "final frontier"—that's space, for those of you who aren't *Star Trek* fans—is always interesting to try. Here are some frequencies you might want to program into your scanner to soar above and beyond the world of taxi dispatchers and other more commonly encountered VHF signals.

A ham-radio satellite called AMSAT-OSCAR 17 ("Dove") can be heard sending out telemetry and occasional bulletins on 145.825 MHz. If you can copy packet (you'll need a TNC) on your scanner, you should be able to start reading tons of data zipping across your screen as soon as Dove comes over the horizon.

There's also some voice traffic on Dove, noted being downlinked on 145.987 MHz (435.016-MHz uplink). Listen during the first four minutes of every 10-minute period past the top of each hour (such as at 0100, 0110, 0120, 0130, etc.). Of course, it can be heard only when the satellite comes over your horizon.

The Russian *Mir* space station is still being heard, and you can put 145.55 MHz into your scanner to hear that one. Mir kicks out a healthy signal, an AX.25 packet transmission that can be read on any TNC. But you don't need a TNC just to hear the data signal—and that's interesting in itself, even if you can't copy the traffic.

Also listen for satellite downlinks (mostly CW and SSB) on 145.857, 145.86, 145.862, 145.90, 145.903, 145.907, 145. 908, 145.910, 145.912, 145.95, 145.953, 145.95, 145.958, 145.96, 145.963, and 146.00 MHz.

There are ham transmissions from many NASA Space Shuttle flights, but the frequencies used differ with each launch.

That's all the room we have for this month, but be sure to join us again in April. Meanwhile, let us know what you're monitoring. Send your scanner-related news clippings, questions, and ideas to *Scanner Scene*, **Popular Electronics**, 500-B Bi-County Blvd., Farmingdale, NY 11735. ■

SONY STR-D990

(Continued from page 29)

watts (the rated output for this channel when using the surround mode). While no specification for this channel is cited by Sony, we measured a distortion plus noise level of 0.31% for this test condition.

HANDS-ON TESTS

Hooking up the STR-D990 to a quintet of loudspeakers and connecting a TV monitor, a VCR, a CD player, and a videodisc player was simple enough. What took a bit of interpretation was the use of those multifunction pushbuttons. While they give the front panel an uncluttered look, they tend to confuse the user who refuses to consult the owner's manual (we're all guilty of that, from time to time). Happily, the last four pages of the owner's manual supplied with the receiver are titled "Quick Reference" and those pages provide step-by-step graphic illustrations of which buttons to push in which order to access the various functions.

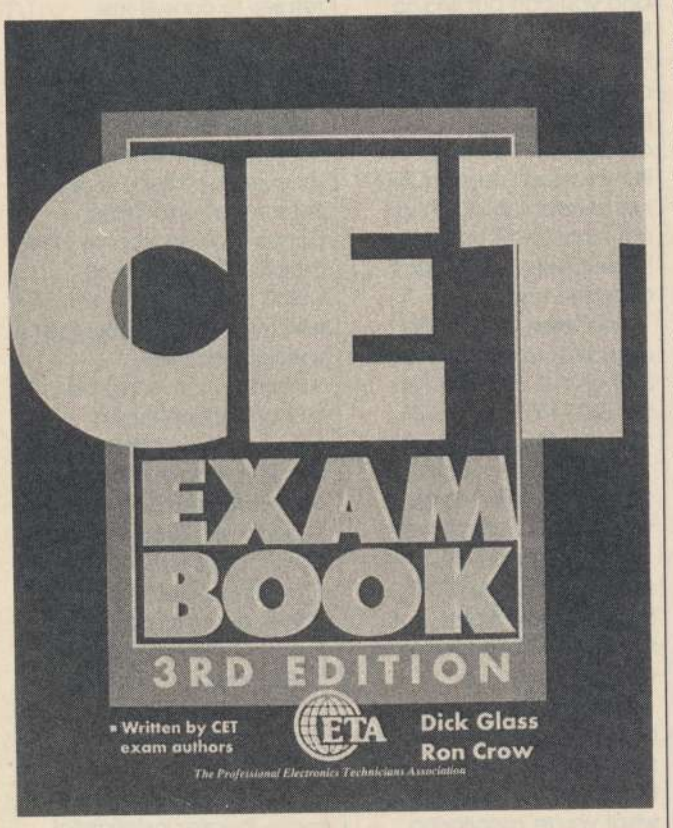
Anyone harboring the misconception that a home-theater installation has to cost many thousands of dollars would do well to consider this receiver. If you own a large-screen TV set, a working stereo system with one or more program sources, and are willing to invest in two or three additional loudspeakers, all you need to add is the Sony STR-D990 and some popcorn to complete your home-theater installation!

For more information on the Sony STR-D990 audio/video receiver, contact Sony (Sony Drive, Park Ridge, NJ 07656) directly, or circle No. 120 on the Free Information Card. ■

ELECTRONICS LIBRARY

CET EXAM BOOK: 3RD EDITION

by Dick Glass and Ron Crow



Written for those who are planning to take the Associate-level Certified Electronics Technician exam for the first time, as well as experienced technicians who are going for a Journeyman, Senior, or Master CET rating, this book contains all the information needed to pass the exams. After an opening chapter that explores the history of the Electronics Technicians Association (ETA) and the CET program, the book goes on to devote a chapter each to such topics as basic mathematics, electrical fundamentals, electronic components, serial and parallel circuits, semiconductors, basic circuits, decibels, antennas and wave propagation, block diagrams, digital concepts, safety, computers, and test equipment and measurements. Other chapters cover various career options in consumer electronics, industrial electronics, telecommunications, satellite TV, biomedical electronics, video distribution, radio communications, and avionics. Each chapter of the book includes a sample quiz that allows readers to gauge their progress and determine which subjects they most need to study. Practice questions and answers are followed by full explanations of all of the principles involved. The third edition has been completely revised and updated to cover every level of CET certification and each of the Journeyman options.

The CET Exam Book, 3rd Edition costs $17.95 and is published by TAB Books, Division of McGraw-Hill Inc., Blue Ridge Summit, PA 17294-0850; Tel. 1-800-822-8138.

CIRCLE 98 ON FREE INFORMATION CARD

VOODOO WORDPERFECT FOR WINDOWS: Tips & Tricks with an Attitude

by Kay Yarborough Nelson

In this book, shortcuts that never appear in traditional manuals are "conjured up." For newcomers as well as advanced users, the book offers an array of tips and techniques intended to make the most of WordPerfect for Windows. The book includes information on installing and upgrading the program, and provides basic graphics and desktop-publishing hints. It explains how to open and close documents, use the Clipboard, take shortcuts when using the mouse and the keyboard, use dialog boxes, and avoid hidden traps. Editorial tips include advice on how to move through documents; select, copy, and paste text; take shortcuts for deleting, hyphenate; and call up the Speller and Thesaurus. The book also reveals secrets to formatting, using the File Manager, and mastering macros. A comprehensive index makes it easy to locate the various shortcuts.

Voodoo WordPerfect for Windows costs $19.95 and is published by Ventana Press, P.O. Box 2468, Chapel Hill, NC 27515; Tel: 919-942-0220; Fax: 919-942-1140.

CIRCLE 90 ON FREE INFORMATION CARD

ELECTRONICS: A SYSTEMS APPROACH

by Neil Storey

Aimed at students and professionals in all major engineering and physics disciplines, this introductory text takes a different approach to electronics, in that its coverage is from a systems perspective. It presents the principles of electronics in an integrated and coherent way by treating analog and digital circuits in one book. Written in a style that is suitable for specialists and non-specialists alike, the book uses a "top down" systems approach to explain the principles of system design. Design case studies highlight the choices and deci-

sions that must be made during the design process. A chapter on system design draws together the similarity of methods used in both analog and digital circuit design.

Electronics: A Systems Approach costs $38.75 and is published by Addison-Wesley Publishing Company, One Jacob Way, Reading, MA 01867; Tel: 617-944-3700.

CIRCLE 91 ON FREE INFORMATION CARD

ELECTRONIC COMPONENTS/ COMPUTER PRODUCTS CATALOG

from Jameco

Jameco's 1993 catalog includes expanded product lines and, for the first time, a variety of education and support information for customers. Intended for customers in the technology, hobby, home, business, and educational markets, the 100-page booklet describes more than 4000 products, ranging from in-

tegrated circuits to computers, to test and measurement equipment. A new, easy-access "Blue Pages" section contains 57 pages of electronic components. The Blue Pages include complete physical specification drawings for engineers, technicians, and purchasing agents, and list discounted quantity and bulk pricing options. Bound inside the 1993 catalog is the "Resources" newsletter, providing in-depth information about company programs and services as well as a review of basic computer and electronics technology.

The 1993 Electronic Components/Computer Parts Catalog is free upon request from Jameco, 1355 Shoreway Road, Belmont, CA 94002; Tel: 415-592-8097; Fax: 415-592-2503.

CIRCLE 92 ON FREE INFORMATION CARD

UNDERSTANDING DATA COMMUNICATIONS Third Edition

by Gilbert Held

This book explains how various computer hardware and software components work and communicate to bring the world together. Filled with reference material and communications, the book helps readers to understand the basics of data communications, define the functions of data terminals and their components, understand the operation of different message and transmission chan-

nels, discover the latest network design techniques and architectures, and understand the Integrated Services Digital Network (ISDN).

An overview explores the basics of data communications and explains real-world connections. The book explains how database services, information utilities, and electronic bulletin boards work. It also explores the inner workings of data terminals, transmission channels, asynchronous modems and interfaces, fiber optics, and satellites. Those concepts and

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principles are accompanied by a thorough look at the world of digital communications; included in that discussion is coverage of such topics as the advantages and disadvantages of local area networks, packet networks, and network design and management.

Understanding Data Communications costs $24.95 and is published by Sams, Division of Prentice-Hall Computer Publishing, 11711 North College, Carmel, IN 46032; Tel: 1-800-428-5331.

CIRCLE 95 ON FREE INFORMATION CARD

THE ART OF SOLDERING

by R. Brewster

If you do hands-on work in electronics, either on the job or as a hobby, then soldering is important to you. While many people believe that proper soldering is a difficult skill to master, and that it is easy to make serious mistakes that are hard to correct later, this book takes the viewpoint that by learning the proper techniques, there's no need to regard soldering as a problem.

The book covers most hobbies that involve soldering, including electronics, model railroads, and stained glass. It explains how to choose the right soldering iron and accessories for the job, and describes in detail the various types of solder. Before explaining how to solder, the book explains the differences between inert and active types of fluxes, and outlines safety procedures. In separate chapters covering electronics, modelling, and stained-glass applications, the book recommends the type of soldering iron, flux, solder, and other tools to use and goes on to explain proper soldering technique. Making repairs and solder-removal techniques are also covered.

The Art of Soldering (order no. BP324) costs $5.95 plus $2.50 shipping and handling, and is published by Electronics Technology Today Inc., P.O. Box 240, Massapequa Park, NY 11762-0240.

CIRCLE 97 ON FREE INFORMATION CARD

BUILD YOUR OWN COMPUTER ACCESSORIES AND SAVE A BUNDLE

by Bonnie J. Hargrave and Ted Dunning

As any computer enthusiast knows, the initial investment for a computer, printer, keyboard, and monitor isn't the end of the required expenditures. You'll be making frequent trips to the computer store for all sorts of accessories intended to enhance the performance of your system or network. This book shows how you can boost your computer productivity by building your own Mac- and IBM PC-compatible accessories.

The do-it-yourself guide outlines 27 money-saving projects,

complete with step-by-step instructions, parts lists, tool requirements, schematics, and illustrations. Featured are hardware enhancements and diagnostic devices including cables and jumpers, port and cable testers, modem and printer switches, power strips, surge protectors, loopbacks, and gender changers. The projects are arranged in order of complexity, beginning with those that even novices can easily handle, such as cables, and progressing to advanced projects recommended for experienced electronics hobbyists; among those advanced projects are a stand-alone RS-232 cable tester and a time-domain reflectometer.

Build Your Own Computer Accessories and Save a Bundle costs $19.95 and is published by Windcrest/McGraw-Hill, Blue Ridge Summit, PA 17294-0850; Tel: 1-800-822-8152. ■

CIRCLE 96 ON FREE INFORMATION CARD

ANTIQUE RADIO

(Continued from page 67)

playback of the message at copying speed. That might have been exactly the method used to alert the sub responsible for the sinking of the *Lusitania,* for it is presumed that WSL forwarded the necessary information. The station at Tuckerton might also have been involved, as mentioned in my earlier column, but it is a known fact that U-boat sinkings declined substantially after seizure of the Sayville station.

Radio WSL (now operating with the call letters NDD) continued to handle supposedly commercial traffic with Germany under the supervision of the U.S. Navy until the U.S. entered the war in 1917. In fact, the infamous "Zimmerman telegram," which offered Mexico a piece of the American Southwest in return for entering the war as a German ally, was sent as an encoded message via Sayville under the eyes of the Navy censors. Later intercepted, that telegram was one of the primary causes of our declaration of war on Germany.

Thanks a lot, Bart, for passing along that fascinating bit of radio history.

THE AMAZING RADIO OF MAX WAX

Also included in Bart Lee's *America's Wireless Spies* book was a cut from *Electrical Experimenter* magazine for June, 1917 showing a sinister looking fellow and a rather advanced-looking electronic device. Since I happened to have that issue, I couldn't resist looking up the story and passing it along.

The sinister fellow, a citizen of Germany, bore the improbable name of Max Wax. He was arrested by

Max Wax and his radio. Was he a spy as well as a con artist? We'll never know.

the New York City Police for working an equally improbable con game on gullible folks of German descent.

The prospective victim would be told that Max's device was a machine built by German scientists to duplicate American banknotes. The dupe would then be persuaded that, if he would place a bill of high denomination inside the machine, ten duplicates would be automatically printed. It would then be the victim's pleasant duty, as a loyal German, to spend the counterfeit money—thus undermining America's economy.

No further details on Max's scam were given, but apparently—once the cash was locked up in the box—the slippery gentlemen found a way to get away with his equipment and the proceeds of his elaborate con game.

After Max was arrested and his equipment confiscated, the device was found in reality to be a miniature radio station containing a receiver capable of picking up messages from Berlin. Was Max actually a German spy using his government-issued equipment to pick up a couple of extra bucks on the side? Maybe, but Max wasn't talking! ■

MONOSTABLE CIRCUITS

(Continued from page 55)

modified signal is fed to pin 2 of the 555. Variable-amplitude output pulses are available via R7, and the timing can be configured in 5 decade ranges by using the values of C3 shown in the table of Fig. 6.

An Analog Frequency Meter. One special application of the 555 pulse generator is as an analog-meter driver in a frequency meter, as in Fig. 7. The IC's pulse output is fed to a 1 mA moving-coil meter (M1) via multiplier resistor R5 and offset-cancelling diode D1; the meter responds to the mean voltage of the pulse waveform (integrated over several trigger cycles), which is directly (linearly) proportional to input frequency.

As shown, this circuit can read up to 1 kHz. By using different values for C3, the full-scale deflection of the meter can range from 100 Hz to 100 kHz. The meter can even read frequencies up to tens of MHz by feeding the inputs to the 555 via a digital divider. ■

ELECTROMAGNETIC FIELDS

(Continued from page 34)

Using the ELF Monitor. To test the unit turn on a television, starting from approximately 2 feet away slowly move the sensor closer to the set. Once you are close enough the green LED will turn off and the red LED will turn on.

As you walk around checking various appliances, you'll probably find by rearrangement you can lower your ELF exposure. For instance that one of my computers has an external power supply that emitted strong ELF radiation, I simply moved the power supply further away from my work space to a more discrete location. Other simple things like changing from a fluorescent desk lamp to an incandescent one will further reduce your exposure.

The ELF monitor can also detect a static magnetic field, when it is moved into or out of the field. If the monitor remains fixed in the magnetic field for a short time the green LED will come back on. ■

EVERYDAY SENSORS

(Continued from page 45)

The transducer is ideal for remote-controled switching to activate external circuits. It can also be used in motion-sensor applications.

An ultrasonic remote-control transmitter is illustrated in Fig. 12A. When the "transmit" button is pressed, the transistor oscillator will drive the sending transducer (TRA1) at about 40 kHz.

The receiver circuit shown in Fig. 12B is typically left on at all times, so it is a good idea to use a small 9-volt power pack to provide energy to the circuit. The receiver is also a bit more complex than the transmitter since it must not only sense the presence of a 40-kHz signal, but provide signal amplification and switching to actuate a relay. The relay will stay on as long as the transmitter is sending. Use a latching relay or other type of latching circuit to keep the output circuit engaged. The circuit should operate well up to about 10 or 15 feet.

Conclusion. Sensors and transducers are so often overlooked and taken for granted, yet they are usually the most important parts of any system. It goes without saying that all the processing power of the most sophisticated computer would be worthless without some means of exchanging data with the outside world. Furthermore, sensors are used in applications ranging from automobiles, aerospace, and security systems, to industrial-process control and data-acquisition systems.

The Electronics Enthusiast's Source Book is a comprehensive, computer-based index of electronics vendors that can provide parts, tools, literature, data, instruments, and materials for all your project and repair needs. Readers who are interested in obtaining more information on "The Electronics Enthusiast's Source Book," or who have any questions or comments about this article, are encouraged to contact me directly at the following address:

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NEW PRODUCTS

General-MIDI Tone Generator

For those who are building their first MIDI music-production system and those looking to increase the sound library of existing systems, as well as multimedia enthusiasts, *Yamaha's TG100* tone generator conforms to the General MIDI specification and provides a "to host" computer connection. General MIDI, a recent addition to the MIDI 1.0 specifications, provides greater compatibility for MIDI song files when they are played on different MIDI equipment. If a MIDI song file that was recorded using the TG100 is played on any other tone generator that conforms to

General MIDI, the assignment of voices to parts will be correct. The "to host" connection allows the TG100 to be connected directly to a computer without a MIDI interface—in fact, in such a set up the unit works as a MIDI interface as well as a tone generator, and other MIDI instruments can be connected to the computer via the tone generator. It can be connected directly to Apple Macintosh and IBM PC/AT/PS2 and compatible computers; computers with a built-in MIDI interface, such as the Atari ST, can be connected using the TG100's MIDI connections. The unit is compatible with most Mac, and some IBM, music software.

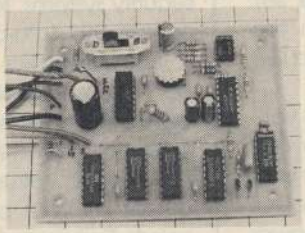
The TG100 generates 192 instrument voices, 10 drum kits, 28-note polyphony, and digital reverb. Its 16-part multitimbrality means that up to 15 different instrument voices and 1 percussion unit can be played simultaneously. Instrument voices and drum sounds are produced using Yamaha's AWM (Advanced Wave Memory) technique, which digitally samples and reproduces sound. The "audio in" feature, conveniently placed on the front panel of the unit, allows an external stereo sound source to be mixed with the sounds produced by the TG100. An input-level control and a signal-peak indicator are provided to help the user during this mix.

The TG100 General-MIDI tone generator has a suggested retail price of $449. For more information, contact Yamaha Corporation of America, P.O. Box 6600, Buena Park, CA 90622-6600; Tel: 714-522-9011.

CIRCLE 101 ON FREE INFORMATION CARD

VOICE SCRAMBLER KIT

The *Voice Scrambler* kit from *Decade Engineering* converts human speech into an unrecognizable garble, allowing the hobbyist to record or transmit secure voice messages in standard media. In its descrambling mode, the device restores fully intelligible speech from the distorted recording or trans-



mission. The design uses digital signal-processing circuitry, which requires no calibration adjustments. A single, switchable PC-board assembly works directly with the builder's cassette-tape recorder to scramble or descramble a spoken message. The supplied speaker is used as a microphone for recording. It's also possible to build a complete, secure telephone system, using a pair of Voice Scrambler kits at each end of the circuit. Each kit includes glass-epoxy PC boards, all electronic components, detailed assembly instructions that contain an explanation of the theory of operation, and a complete schematic diagram of the voice-scrambler circuit.

The Voice Scrambler kit costs less than $35. For additional information, contact Decade Engineering, 2302 5th Street NE, Salem, OR 97303; Tel: 503-363-5143; Fax: 503-399-9747.

CIRCLE 102 ON FREE INFORMATION CARD

TV/VCR COMBINATION

Intended for business presentations as well as personal use at home, in a car, or on a boat, the *Memorex Model 17* from *Tandy* is a 5-inch color TV and 8mm VCR combination in one space-saving cabinet. It plays 8mm prerecorded tapes, or records tapes from an 8mm camcorder, another VCR, or the TV tuner. The Model 17 also can play tapes on an external video monitor or any TV with A/V input jacks. Features include digital auto-tracking control that constantly adjusts tape tracking,

a flying erase head for improved editing, a real-time counter with memory, freeze frame, and on-screen displays. The TV portion has a 179-channel, digital PLL cable-compatible tuner, easy-access A/V in/out jacks for monitoring 8mm camcorders playing recordings on a larger screen, or dubbing from any

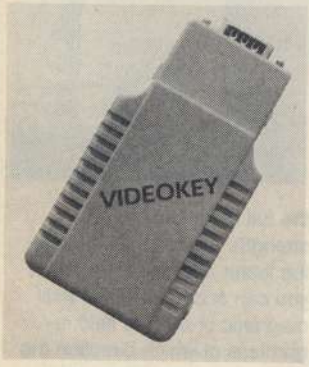
format. The TV/VCR has a built-in telescoping antenna, an external antenna jack, and an earphone jack. It comes with an AC adapter and a DC power cord.

The Memorex Model 17 TV/VCR combination (Cat. no. 16-409) sells for $799.95 at Radio Shack stores nationwide. For further information, contact Radio Shack, Division of Tandy Corporation, 700 One Tandy Center, Fort Worth, TX 76102.

CIRCLE 103 ON FREE INFORMATION CARD

VGA/TV CONVERTER

You can turn your notebook computer into a portable presentation tool using *Advanced Digital Systems' Videokey*. The palm-sized device allows the signal from an external VGA port to be converted for display on any broadcast-ready color television set. Designed for the notebook or laptop user who would like to take full advantage



of the on-board VGA card, the Videokey allows any program to be viewed in a large, color format using readily available TV sets and broadcast-standard monitors. The device supports video modes of resolutions up to 640×480 with 256 colors. Interconnection is via RCA jacks or S-VHS connectors for improved resolution. All necessary cables and software drivers are included.

The Videokey VGA/TV converter has a suggested retail price of $299. For additional information, contact Advanced Digital Systems, 20204 State Road, Cerritos, CA 90701; Tel: 310-865-1432; Fax: 310-809-6144.

CIRCLE 104 ON FREE INFORMATION CARD

MINI DC/AC CLAMP METER

The *Mini DC/AC Current Clamp Meter* from *Extech Instruments* allows technicians to clamp onto a single wire to measure AC (20/200 amps) and DC (200 amps) current, AC (500 volts) and DC (200 volts) voltage, and resistance to 200 ohms. Accuracy is 1.2% of the reading. The compact test instrument measures 7.1×1.9×1.4 inches, weighs only eight ounces, and has a ¾-inch jaw opening. The clamp-on meter features a bright ½-inch LCD readout with data-hold function, low-battery and over-range indicators, and

a sampling rate of 2.5 times per second. Also featured are overload protection and, for direct current measurements, an external zero-adjust knob. The clamp-on meter comes with test leads, a 9-volt battery, and a carrying case.

The Mini DC/AC Current Clamp Meter (model number 380652) costs $149. For additional information, contact Extech Instruments Corporation, 335 Bear Hill Road, Waltham, MA 02154; Tel: 617-890-7440; Fax: 617-890-7864.

CIRCLE 105 ON FREE INFORMATION CARD

METAL DETECTOR

For use in a variety of treasure-hunting applications—from deep digs to wet sand searches—the *CZ-5 QuickSilver* from *Fisher Research Laboratory* offers a visual target-ID meter, three-tone audio target ID, big-target alert, depth reading, pushbutton pin-pointing, and a built-in speaker. The unit's easy-to-read meter, which requires no programming, displays seven small-target categories. In addition, the unit's three-tone audio target ID generates a low tone to indicate a ferrous target, a medium tone

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for a pull tab or foil, and a high tone for a coin. A distinctive bell tone warns you of a big target. At the push of a button, the sound pitch and meter needle rise to indicate that you're approaching the target, and peak right over it. The meter gives a depth reading in inches for coin-sized objects. By flipping a switch and readjusting the ground control, you can use the CZ-5 QuickSilver for wet-sand searches. For deep-target searches, the audio-boost volume control keeps fixed, shallow-target response at a fixed level but amplifies faint, deep-target sounds.

The CZ-5 QuickSilver metal detector has a suggested retail price of $850. For more information, contact Fisher Research Laboratory, Department 6MO, 200 West Willmott Road, Los Banos, CA 93635; Tel: 209-826-3292.

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TRANSCEIVER/ COMPUTER INTERFACE CABLES

Designed to interface personal computers with all receivers and transceivers that can be controlled over a serial TTL link, *j-Com's Transceiver Control Computer Interface Cables* act as direct replacements for the manufacturers' own units, making them fully compatible with all rig-control software. Unlike manufacturer-supplied interfaces, j-Com's cables require no external power supply. The small amount of power needed can be "borrowed" directly from the computer's serial interface. Removing the external power supply significantly reduces the interface's susceptibility to RFI from the transmitter, which can affect the serial transmissions between the computer and the rig, or be transferred to the transceiver or computer. Emitted RF noise also is reduced.

The entire interface has been sandwiched into the shielded hood of a DB-25 connector compatible with the serial interface of most PC-compatible computers. For use with computers that have the smaller-size AT connector, an optional

DB-9-to-DB-25 adapter is available. The unit comes fully assembled and ready to plug in. It is available in four models: the *TC-I* for all Icom and Ten-Tec rigs; the *TC-K* for all Kenwood rigs; and the *TC-Y1* and *TC-Y2* for various Yaesu models.

All four models of Transceiver Control Computer Interface Cable are priced at $54.95 (plus $5 shipping and handling). For more information, contact j-Com, Box 194, Ben Lomond, CA 95005; Tel: 408-335-9120; Fax: 335-9121.

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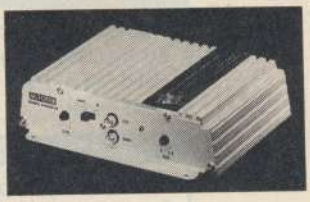
CAR-STEREO AMPLIFIER

Autotek's 7040BTS is a compact, two-channel amplifier that delivers 18 watts per channel into 4 ohms, and 36 watts per channel into 2 ohms. The amplifier is equipped with a two-way input-selector switch that allows the user to take advantage of the built-in bass boost, or to bypass the boost circuit for a



cleaner output. When bass boost is selected, it is fully adjustable from 0–18 dB, centered at 45 Hz. Input sensitivity ranges from 190 mV to 3.5 volts, signal-to-noise ratio is 91 dB, and the damping factor is greater than 80. Maximum current consumption is 10 amps. The amplifier is fully bridgeable, and will run in mixed mono (simultaneous satellite and subwoofer) configuration. A high-value emitter resistor and a bypass diode in the unit's circuitry provide a bright musical output with virtually no crossover distortion.

The model 7040BTS car-stereo amplifier has a suggested retail price of $199. For additional information, contact Autotek, 855 Cowan Road, P.O. Box 4391, Burlingame, CA 94011-4391; Tel: 415-692-2444; Fax: 415-692-2448.

CIRCLE 108 ON FREE INFORMATION CARD

PRINTER-SHARING DEVICES

Each of the three *Sprinter II* models in *Belkin Components'* line of intelligent printer-sharing devices permits multiple users to share multiple printers. Each user can send data to the printer of his choice. The Sprinter II then queues the data in its buffer and directs it to the user-specified printer in the order it is received. That allows users to continue working on other tasks while their documents are printing. Each Sprinter unit has 256K of memory, upgradable to a total of 16 megabytes using standard 256K, 1-Meg, or 4-Meg SIMM's. In addition, up to nine Sprinter II

units can be cascaded to allow as many as 92 users to share up to 36 printers. The devices also allow users to select the baud rate, produce multiple copies of print jobs, set user priority, redirect data to different printers, select and change default printers, change time-out settings, prioritize print jobs, and produce form feeds and title pages between documents.

Each Sprinter II model offers two serial and two parallel output ports. *Models F1X404*, F1X408, and *F1X412*, offer four, eight, and twelve serial input ports, and have suggested list prices of $499, $624, and $729, respectively. For more information, contact Belkin Components, 1303 Walnut Park Way, Compton, CA 90220; Tel: 310-898-1100 or 800-2-BELKIN; Fax: 310-898-1111.

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TRI-FIELD METER

For those who require meters that read AC electric fields, AC magnetic fields, and radio/microwaves, *AlphaLab* offers the *Tri-Field Meter*. Its measurements are made with multi-directional sensors that read field strengths in all directions simultaneously, for measuring

the full magnitude of field strength. That makes measuring faster and easier, because you can accurately read total magnetic or electric field regardless of which direction the meter is pointing. The meter reads all three types of fields both numerically and with a safe, borderline/high scale that is weighted proportional to the effect in the body. Thresholds are based on epidemiological and laboratory studies, whose results indicate that reduction of relative exposure is prudent. The compact meter comes ready-to-use with battery, instructions, and a one-year limited warranty.

The Tri-Field Meter costs $144 postpaid (in Canada, add $10 shipping). For more information, contact AlphaLab, 1272 East Alameda Avenue, Salt Lake City, UT 84102-1703; Tel: 503-621-9701. ■

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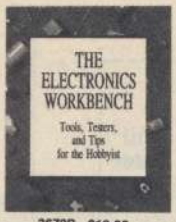

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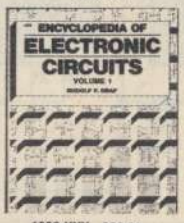

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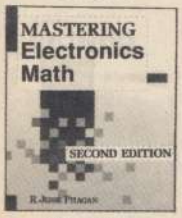

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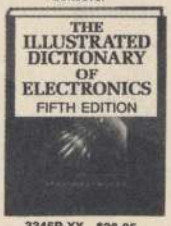

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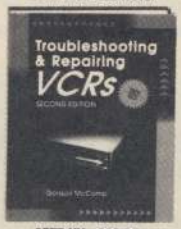

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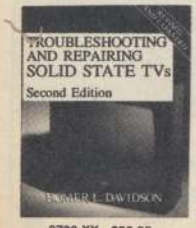

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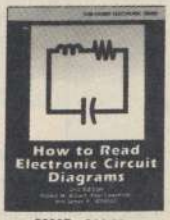

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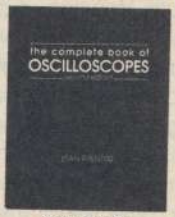

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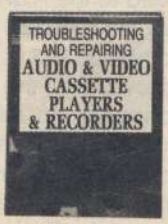

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CIRCUIT CIRCUS

(Continued from page 70)

speed oscillator is connected to one input of U1-c, while the output of the low-speed oscillator is fed to the input of U2-c. The other inputs of U1-c and U2-c are connected together and serve as the override input. A logic low at the override input inhibits both oscillators, preventing them from outputting a signal to U1-d or U2-d, respectively.

When the override input is deactivated, the selected oscillator signal is fed through either U1-c and U2-c (both of which will invert its respective oscillator signal) and U1-d and U2-d (which performs a second inversion, returning the signal to its original form). The outputs of U1-d and U2-d are coupled through a pair of diodes to a common output, and applied to the clock input of counter (U2) at pin 14 in Fig. 2.

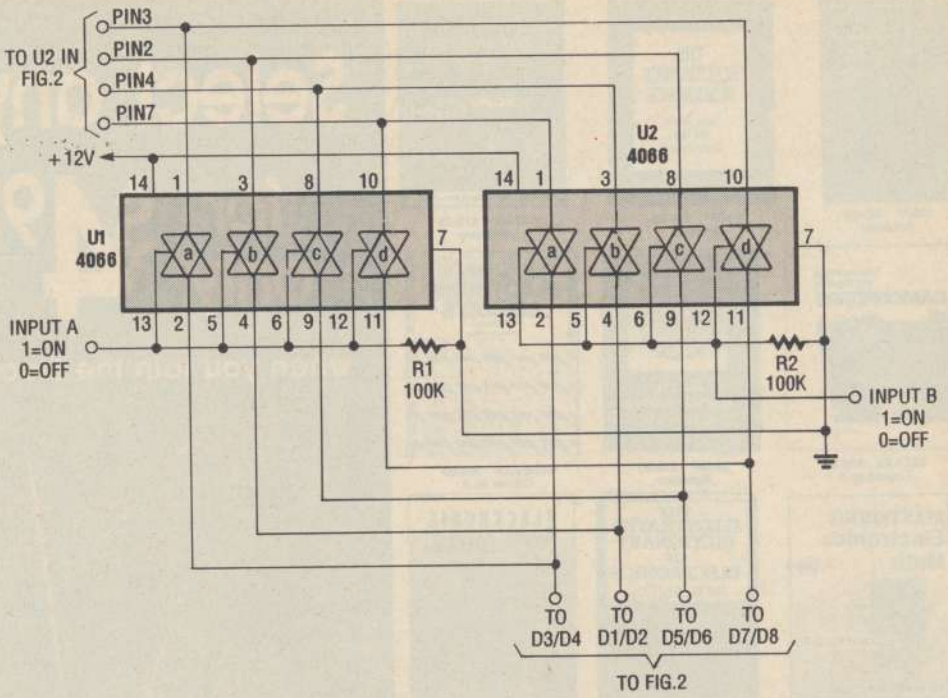


Fig. 5. The stepper motor's direction of rotation is reversed by reversing the drive delivered to the motor. That can easily be accomplished through this bilateral-switch control circuit.

PARTS LIST FOR THE DUAL-OSCILLATOR

RESISTORS

(All fixed resistors are ¼-watt, 5% units.)
R1–R3—100,000-ohm
R4—10,000-ohm
R5, R6—500,000-ohm potentiometer

ADDITIONAL PARTS AND MATERIALS

U1, U2—4011 CMOS quad NAND gate, integrated circuit
D1, D2—1N914 general-purpose silicon diode
C1—0.01-μF, ceramic-disc capacitor
C2—0.047-μF, ceramic-disc capacitor
Perfboard materials, enclosure, sockets, 12-volt power source, wire, solder, hardware, etc.

PARTS LIST FOR THE REVERSE DRIVE CIRCUIT

U1, U2—4066 CMOS quad bilateral switch, integrated circuit
R1, R2—100,000-ohm, ¼-watt 5% resistor.
Perfboard materials, enclosure, IC sockets, 12-volt power source, wire, solder, hardware, etc.

REVERSE DRIVE CIRCUIT

Our final circuit for this month (see Fig. 5), which is built around two 4066 quad bilateral switches, allows the stepper motor's direction of rotation to be reversed by reversing the drive delivered to the motor. (The sequence is shown in Table 1).

The input to the Fig. 5 circuit is connected to the output of the 4017 counter (in Fig. 2) as indicated (in effect connecting each output of the 4017 to two of the bilateral switches, one in each IC). The outputs of the bilateral switches are connected together, as shown, and fed through the steering diodes to the selected driver circuit (either the hexFET or bipolar-transistor version).

A low at input A and input B (in Fig. 5) opens the bilateral switches so no signal is passed to the driver circuits. However, if a high is applied to input A while input B is held low, all of U1's switches will close, feeding a signal to the driver circuits, and causing the motor to rotate in the forward direction. If the signals applied to the A and B inputs are reversed (*e.g.*, a logic high to B and input A held low), all of the U2 switches turn on, reversing the order of the output, which causes the motor to rotate in the opposite direction.

Looks like we've just about run out of space for this month. See you same time same place next month. ■

"The plug fits fine, Dad, I just had to cut off a few pins"

SMART HIGHWAYS

(Continued from page 60)

Fig. 4), that, while looking like standard posts, are much more sophisticated. Small radio transmitter/receivers are buried in the base of the post with only the antenna projecting above the ground from inside the post. The posts are also fitted with multi-colored, usually red and yellow, flashing lights.

Cars and trucks would also be equipped with an electronic unit that could communicate with the receivers/transmitters in the posts. The posts themselves would be linked together and to a central emergency-control center via buried cable.

When an accident occurs, an electronic "SOS" could automatically be transmitted from the vehicles involved to the nearby roadside post. The crash could be sensed, for example, by an accelerometer similar to ones used to trigger the inflation of an airbag. The information would then be transmitted from the post to the emergency center. Center personal would not only know of the accident, but also its precise location. The marker posts are located about 50 meters (164 feet) apart for high information density, so the location of an incident can be accurately pinpointed. Ambulances and other emergency vehicles could be dispatched immediately. A flashing colored light would be activated to warn other drivers to prevent chain-reaction accidents.

COMPANION could also be used in several other emergency situations. For example, in case of a breakdown, the driver could press a dashboard button to send a signal to the post that would result in the control center dispatching a tow truck. Again the flashing lights would be turned on to warn drivers of a disabled vehicle in the road ahead. COMPANION is especially valuable on a road with restricted visibility.

The warning lights could be automatically activated by weather sensors to warn of dangers like black ice or fog ahead. They could also be turned on by the police or highway-maintenance personnel. The system could even be used to detect a driver going in the wrong direction and warn other drivers and help apprehend the errant driver. Taxis, for example, could be fitted with a concealed button that would provide a silent alarm to be sent if there was a problem with a passenger.

Automatic vehicle-theft notification and monitoring could also be adapted with the signal triggered by an anti-theft device. With widespread installation, each vehicle could transmit data as to vehicle type and speed. This information could be used to measure traffic density and identify congestion problems for use in preparing traffic advisories.

The PROMETHEUS staff is investigating the entire spectrum of needs for smart cars for smart highways. Thus investments are also being made in many technologies that are required to make the concept work and yet remain economically feasible. These include artificial intelligence (PRO-ART), vehicle-to-vehicle communications (PRO-NET), vehicle-to-environment communications (PRO-ROAD), computer hardware (PRO-CHIP), etc.

It is interesting to note that although we've only covered some of the PROMETHEUS projects, the few we've discussed promise significant changes in the way people drive. Only time will tell how great the effect of the complete system will be once instituted. ■

FUEL MISER

(Continued from page 39)

Such thermostats have two sets of contacts that close at slightly different temperatures, and are wired so that the burner can start only when both sets of contacts are closed. That type of system is shown in Fig. 6. To install Fuel Miser in such systems, simply connect the Fuel Miser's output terminals in series with one of the relay coil connections, as shown.

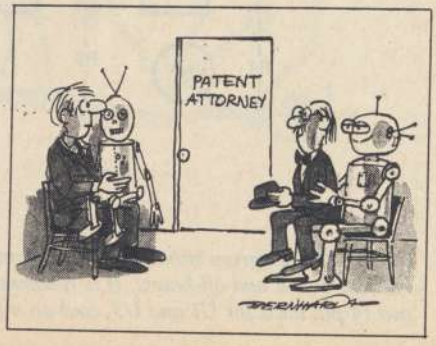
Electric-heating systems may or may not use a relay in the thermostat circuit. Those that do have a relay can be controlled by Fuel Miser by wiring its output circuit in series with the relay coil connections as shown in Fig. 7. Electric-heating systems that do not contain a low-current thermostat (as in the previous installation examples), use a heavy-duty thermostat that directly feeds current (as shown in Fig. 8) to the heating element, without the use of a relay or contactor. For such systems, it will be necessary to install a heavy duty relay (as shown in Fig. 8) to control the heavy heating-element current. The voltage and current rating of the relay must be equal to or greater than the electrical requirement of the furnace.

Final Test. After installing the Fuel Miser, apply power to both the heating system and the Fuel Miser. Set the duty cycle (via S1) to 100%, and check the furnace for normal operation when heat is called for by the thermostat. At the 100% duty cycle setting, the heating system should operate normally—as it did prior to the installation of the Fuel Miser.

If all is well, set S1 to 10% and turn the thermostat up as high as it will go to force the system to call for constant burner operation. Time the operation of the burner for at least two complete Fuel Miser cycles. For gas systems the valve should be powered for about 45 seconds and be off for about 7 minutes. (The gas flame may start and stop after a time lag). For oil systems, the burner should operate for 3½ minutes and be off for 31½ minutes.

That completes the checkout of the Fuel Miser, and it is ready to control your heating costs. A good starting point for the Fuel Miser's operation is at the 70% duty-cycle setting; try that setting for a day or two. Remember, try to keep a constant thermostat setting during the test period to see how the Fuel Miser operates in your system.

With some experimenting, you'll be able to determine which duty cycle is best. Remember, the lowest duty cycle that still provides sufficient comfort will provide the greatest savings. ■



AN ELECTRONIC GONG

(Continued from page 65)

semiconductors (BR1, D1, and Q1) except the IC's. Follow that with transformer T1. In the prototype, T1 was mounted to the board using a couple of nuts and bolts. Next, you must decide on a location for SPKR1. The mounting location for the speaker depends on the circuit's intended use and housing. (In the author's case, the speaker was fastened inside the base of the tea-maker using a self-tapping screw.)

Once you've mounted SPKR1, connect short lengths of hook-up wire between the circuit board and the speaker. Finally connect, a 117-volt AC source to the appropriate points on the circuit. In the author's prototype installation, the AC source was tapped directly from the tea machine's internal wiring.

Check Out. Before applying power to the circuit, it is wise check the assembly for construction errors, such as solder bridges (shorts) between traces, cold solder joints, misplaced and misoriented components, etc. Once you are satisfied that the circuit contains no errors, it time to put the circuit through its paces. Install the IC's in their sockets, making sure that they are properly oriented.

With a project that's powered by the AC line, it is often a good idea to first test the circuit using a regulated, low-voltage DC power supply. The circuit is in no way fussy about the supply voltage, and will operate on any voltage from about 9 volts (below which the LM380 does not perform reliably) to 15 volts (above which CMOS IC's like the 4001 tend to get zapped).

With power applied, adjust R10 until the twin-T network is just about to oscillate; working from there, decrease R10's resistance until the circuit oscillates steadily. After that, increase R10's resistance until the oscillations fade to silence (as shown in Fig. 6). If R10 is set to its maximum resistance, there will be fast decay, or perhaps even no oscillation. With R10 at the other end of its rotation, oscillation should be constant, *i.e.*, no decay.

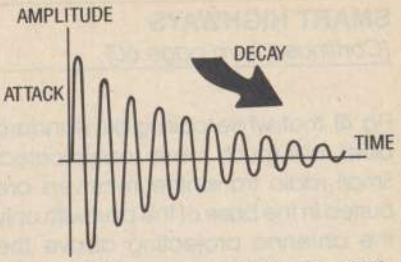


Fig. 6. With power applied, adjust R10 until the twin-T network is just about to oscillate; working from there, decrease R10's resistance until the circuit oscillates steadily. After that, increase R10's resistance until the oscillations fade to silence, as shown here.

The preferred setting will be influenced by the triggering period. With the RC component values used in the oscillator circuit (U1-a and U1-b), the delay between pulses was about 12 seconds. With R10 set very critically, for maximum decay and reverberation, the sound may not have completely disappeared when the next trigger pulse arrives. Finally, R11 should be adjusted to give the required volume level.

Other Uses. I have used essentially the same circuit in a car-alarm unit to provide a repetitive warning alert during the exit and re-entry periods. It is also triggered to give between one and four chimes on detecting various conditions such as low fuel, low washer fluid, and icy temperatures.

I've also built a little electronic-percussion unit with 11 switchable sounds across the frequency spectrum, which was fun to make and play with. Lots of other possibilities come to mind, such as using it in a prowler alarm, a proximity detector, or (with some challenging logic circuitry) as a clock chimer. ■

"This usually brings them out of hiding"

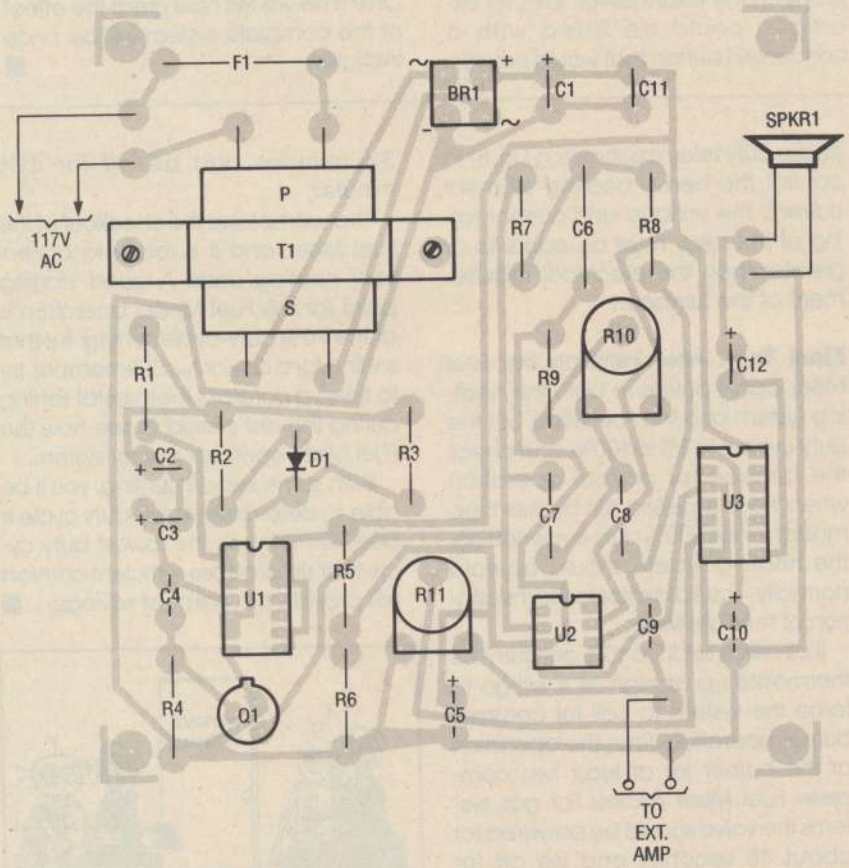


Fig. 5. This diagram shows the component locations for all of the circuit elements, both on-board and off-board. It is recommended that sockets be provided for the IC's; two 14-pin units for U1 and U3, and an 8-pin unit for U2.

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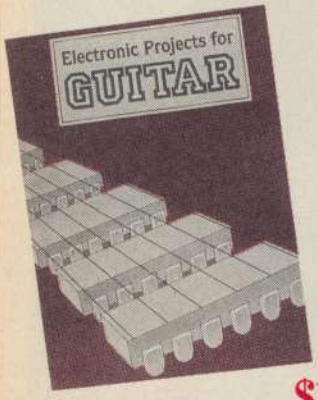

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ADVERTISING INDEX

POPULAR ELECTRONICS magazine does not assume any responsibility for errors that may appear in the index below.

Free Information No.		Page
7	AMC Sales	87
—	Antique Radio Classified	96
—	CBC International	95
—	CIE	25
—	Cable Ready Company	97
—	CLAGGK Video Offer	CV4
—	Command Productions	83
12	Cook's Institute	87
11	Davis Instruments	26
—	Electronic Tech. Today	CV2, 97
—	Electronics Book Club	19, 91
—	Firestik II	95
—	Grantham College	85
10	Heathkit	79
—	HighText Publications, Inc.	83
—	ISCET	74
8	Jameco	15
15	MCM	69
—	NRI Schools	11
—	Nu-Tek	95
9	Panavise	75
6	People's College	3
—	Phillips Tech	96
—	Popular Electronics	30
—	Silent Sam TSR Co.	96
—	T.K.A. Electronics	29
5	The School Of VCR Repair	77
14	U.S. Cable	26
—	USI Corp.	96
—	Video Dimensions	83
—	Weeder Technologies	96
13	Zentek Corp.	26

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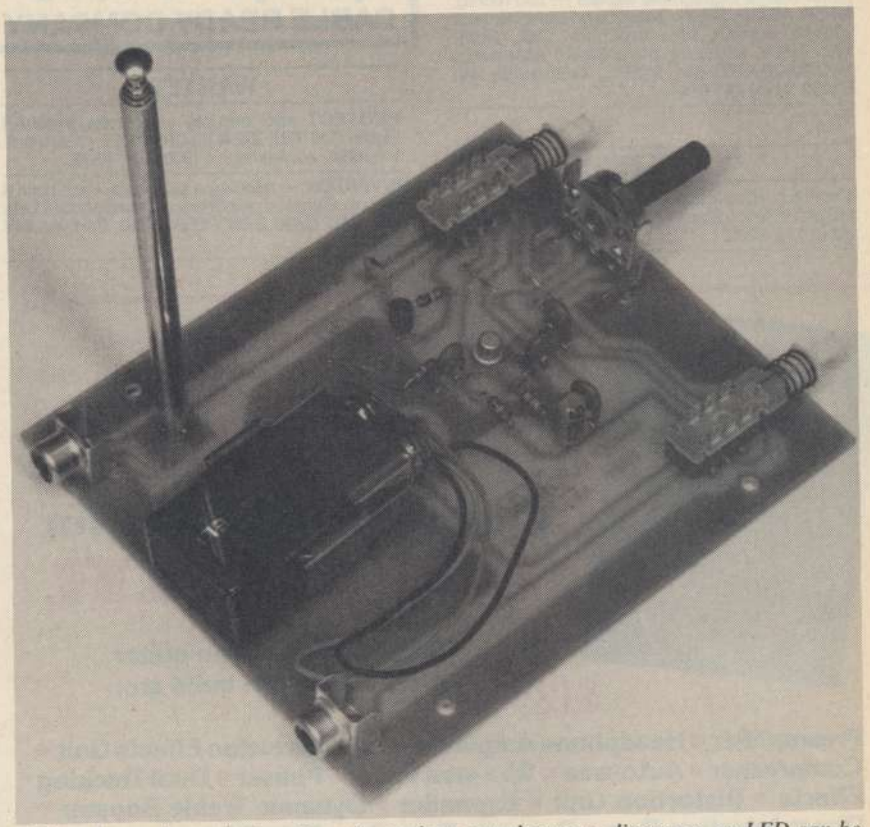
BUILD AN ACTIVE ANTENNA

(Continued from page 48)

using the whip antenna, simply connect the output of the AA-7 to your receiver, with the unit turned off (that's the bypass position) and the RF gain control (R5) turned fully counterclockwise. Turn on the receiver and tune-in a weak station. Switch S2 on, and adjust the gain control clockwise to increase the output signal. Toggle S1 back and forth to see which setting gives you the best results. Don't be surprised if the gain control overloads the receiver; if so, back it off.

There are other characteristics or phenomena associated with preamplifiers and active antennas that does not mean that your the circuit is malfunctioning. For example, if you have strong AC hum in the HF setting, the antenna is too close to an AC cord or power line. HF signals may be clearer at the VHF/UHF setting than at the HF setting. Why? Although either preamp may be used for HF, the signal strength will be greater with the VHF/UHF preamp. However, the HF signal-to-noise ratio is better with the dual-gate-MOSFET-based preamp. Try both and use the best for your particular receiving conditions.



Although not shown in the schematic or the parts-placement diagrams, an LED can be added to the circuit so that you can tell at a glance if the circuit is on. In his own unit, the author accomplished that by connecting the LED (with a series-connected current-limiting resistor) between a terminal on the power switch and the grounded frame of the gain control (R5).

Troubleshooting. The fact that there are two independent preamplifiers in the AA-7 makes faults easier to diagnose than with many other devices. If a problem occurs, only at one setting of S1, concentrate on that part of the circuit. If the problem is common to both settings, the components and connections common to both preamps should be checked. Make sure the jumper wires are in place.

Some portable receivers not enclosed in metal cases may break into oscillation when connected to any RF preamplifier. Try reducing the AA-7's gain and make sure that good grounds are provided with the interconnecting coax cables. A preamplifier will intensify any problems due to poor receiver design: overloading, images, or any problems with selectivity and image rejection. ■

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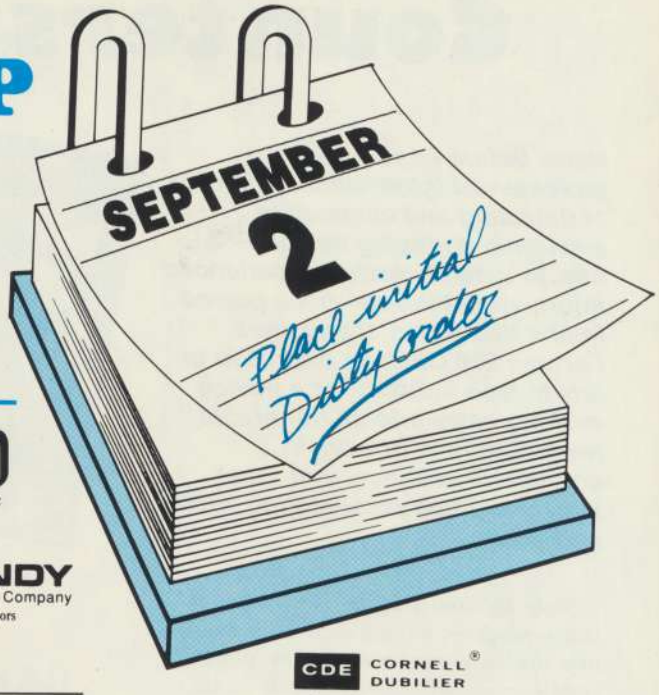

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Wake up! You may be the victim of stolen words—precious ideas that would have made you very wealthy! Yes, professionals, even rank amateurs, may be listening to your most private conversations.

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There is a thriving professional service steeped in high-tech techniques that you can become a part of! But first, you must know and understand Countersurveilance Technology. Your very first insight into this highly rewarding field is made possible by a video VHS presentation that you cannot view on broadcast television, satellite, or cable. It presents an informative program prepared by professionals in the field who know their industry, its techniques, kinks and loopholes. Men who can tell you more in 45 minutes in a straightforward, exclusive talk than was ever attempted before.

Foiling Information Thieves

Discover the targets professional snoopers seek out! The prey are stock brokers, arbitrage firms, manufacturers, high-tech companies, any competitive industry, or even small businnesses in the same community. The valuable information they filch may be marketing strategies, customer lists, product formulas, manufacturing techniques, even advertising plans. Information thieves eavesdrop on court decisions, bidding information, financial data. The list is unlimited in the mind of man—especially if he is a thief!

You know that the Russians secretly installed countless microphones in the concrete work of the American Embassy building in Moscow. They converted what was to be an embassy and private residence into the most sophisticated recording studio the world had ever known. The building had to be torn down in order to remove all the bugs.

Stolen Information

The open taps from where the information pours out may be from FAX's, computer communications, telephone calls, and everyday business meetings and lunchtime encounters. Businessmen need counselling on how to eliminate this information drain. Basic telephone use coupled with the user's understanding that someone may be listening or recording vital data and information greatly reduces the opportunity for others to purloin meaningful information.

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The professional discussions seen on the TV screen in your home reveals how to detect and disable wiretaps, midget radio-frequency transmitters, and other bugs, plus when to use disinformation to confuse the unwanted listener, and the technique of voice scrambling telephone communications. In fact, do you know how to look for a bug, where to look for a bug, and what to do when you find it?

Bugs of a very small size are easy to build and they can be placed quickly in a matter of seconds, in any object or room. Today you may have used a telephone handset that was bugged. It probably contained three bugs. One was a phony bug to fool you into believing you found a bug and secured the telephone. The second bug placates the investigator when he finds the real thing! And the third bug is found only by the professional, who continued to search just in case there were more bugs.

The professional is not without his tools. Special equipment has been designed so that the professional can sweep a room so that he can detect voice-activated (VOX) and remote-activated bugs. Some of this equipment can be operated by novices, others require a trained countersurveillance professional.

The professionals viewed on your television screen reveal information on the latest technological advances like laser-beam snoopers that are installed hundreds of feet away from the room they snoop on. The professionals disclose that computers yield information too easily.

This advertisement was not written by a countersurveillance professional, but by a beginner whose only experience came from viewing the video tape in the privacy of his home. After you review the video carefully and understand its contents, you have taken the first important step in either acquiring professional help with your surveillance problems, or you may very well consider a career as a countersurveillance professional.

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To obtain the information contained in the video VHS cassette, you would attend a professional seminar costing $350-750 and possibly pay hundreds of dollars more if you had to travel to a distant city to attend. Now, for only $49.95 (plus $4.00 P&H) you can view ***Countersurveillance Techniques*** at home and take refresher views often. To obtain your copy, complete the coupon or call.

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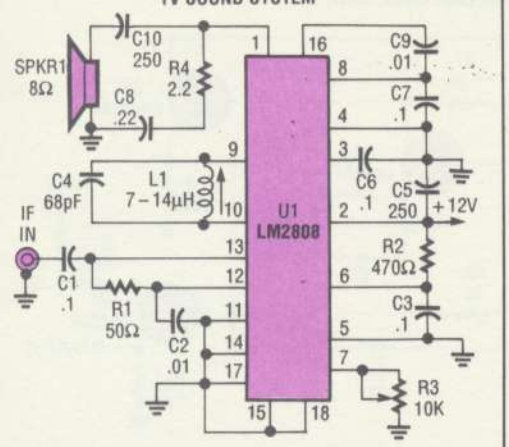

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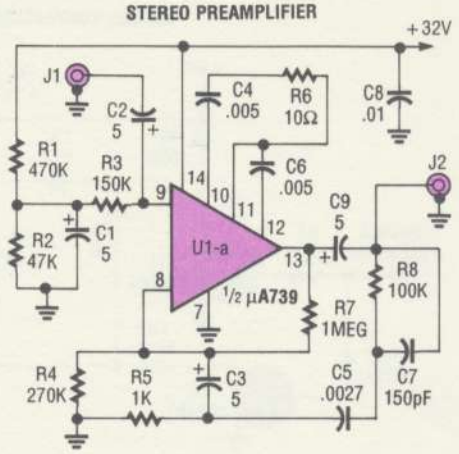

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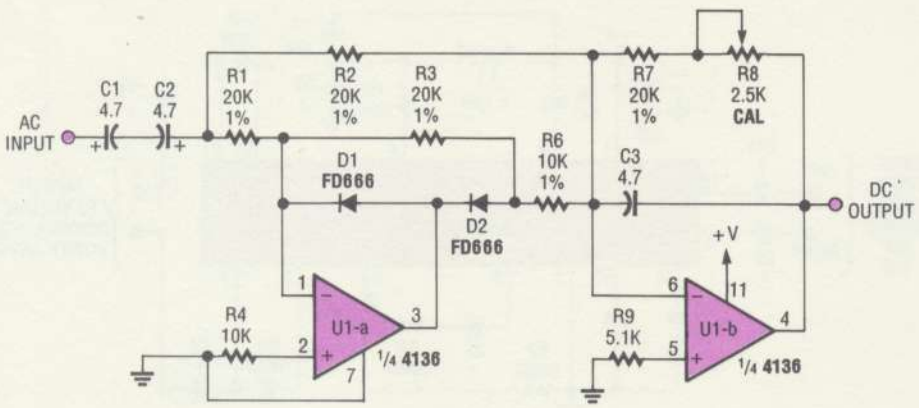

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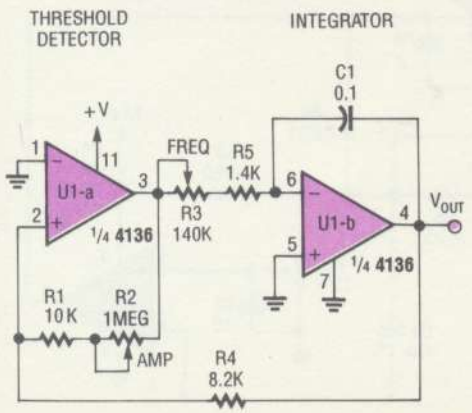

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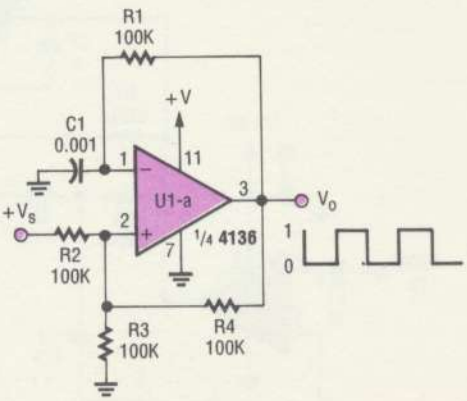

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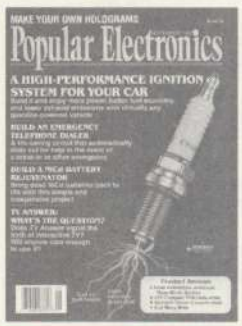

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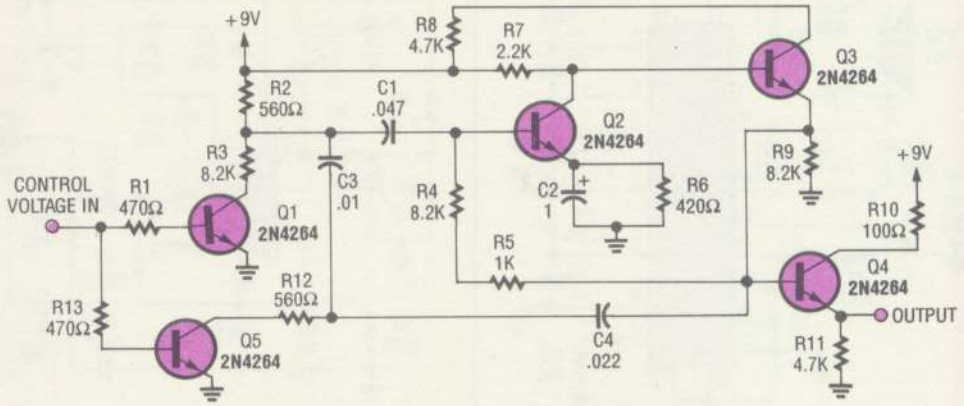

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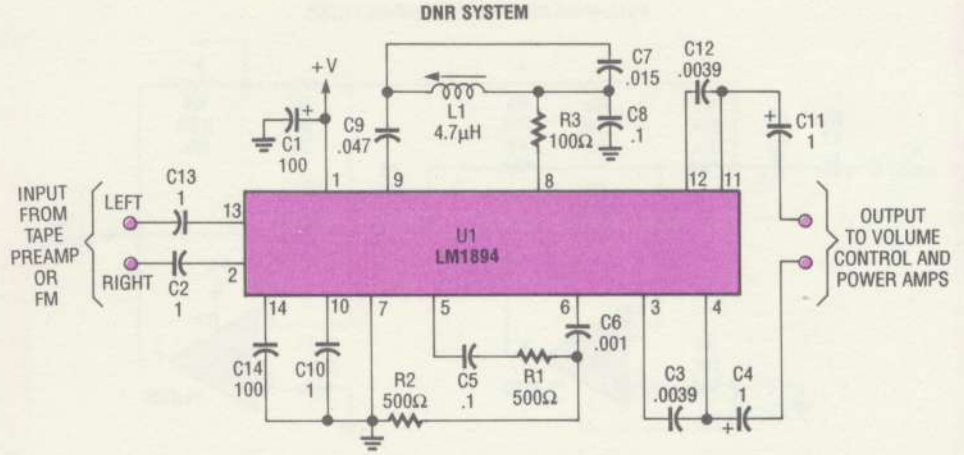

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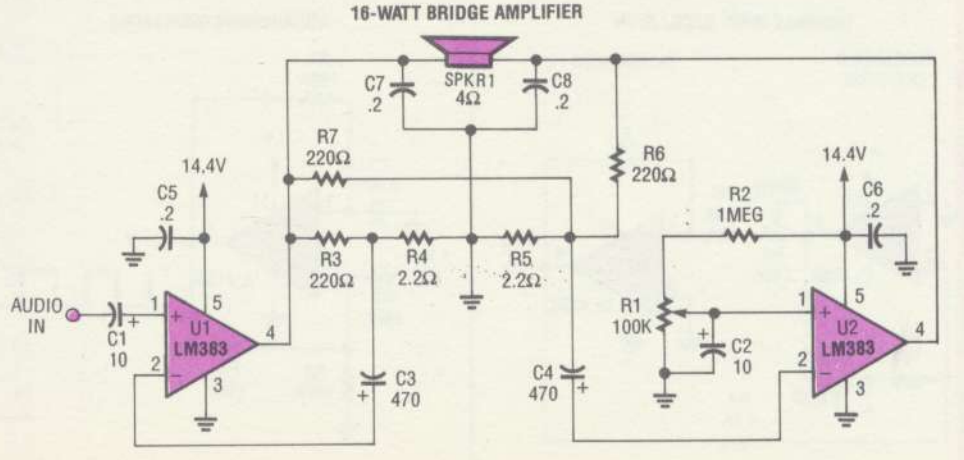

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